Using Physical Soil Amendments, Irriga

SUMMARY

Among the soil amendments, peat has the advantages of promoting a very good top growth and dense root system, when properly irrigated to avoid poor aeration. It has the disadvantages of not being able to withstand compaction and can become excessively wet if proper irrigation practices are not followed. Lignified wood has the advantages of withstanding compaction, providing high infiltration rates, allowing good aeration, maintaining an extended supply of nitrogen under leaching conditions, and promoting a good root system under a high oxygen diffusion rate (ODR). It has the disadvantages of contributing to soil salinity, and apparently requires a higher ODR for maximum root growth. Calcined clay has the advantages of withstanding compaction, providing high infiltration rate and allowing for good aeration. Its disadvantage is that although it promotes deep roots, they are rather sparse with few roothairs.

Better results were obtained with irrigation based upon tensiometer records than by irrigation according to a set calendar schedule. Advantages over the set program chosen for this experiment included a savings in water, improvement in soil aeration, and reduction in soil compactability. One requirement in irrigating by tensiometer records is that excess water must be applied periodically to cause leaching, if salinity becomes too high.

The wetting-agent treatment (at only 3 ppm), increased the infiltration rate of the unamended soil, reduced compactability of peat-amended soil, and also resulted in some other effects of minor significance. Other research in progress indicates that the relationships between wetting agents and plant growth are extremely complex, and no general conclusions are likely for some time.

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TURFGRASSES ARE GROWN for their beauty and durability under recreational uses. They are subject to soil compaction by foot traffic and equipment used in management operations. Soil compaction may adversely affect root growth, elongation, soil-water relationships, and soil aeration. This report resulted from a greenhouse experiment at the Riverside campus to determine the effect of (1) physical soil amendments, (2) compaction, (3) irrigation, and (4) wetting agents on growth of turfgrasses.

Soil amendments

Soil with poor structural stability was amended (⅓ each by volume) with sphagnum peat moss, lignified wood, and calcined clay. (Wood products are lignified by treatment with sulfuric acid and heat, and then neutralized with anhydrous ammonia so that the resulting product has a high content of lignin and lignin-related products.)

Special containers were constructed from plexiglass for use in this experiment. They were 4 inches in diameter and 17 inches high. Tensiometer cups were inserted through holes on the side of the containers at depths of 3 inches and 8 inches.

A hole was drilled at the bottom of each container for drainage, and a short piece of plexiglass tubing was sealed in the hole. Rubber tubing was used to conduct drainage effluent from the containers to bottles placed directly beneath the containers.

A 2-inch layer of coarse sand was placed in the bottom of the containers. The soil mixes were placed in the containers over the sand layer. Since the lignified wood contained 1% nitrogen, equivalent amounts of nitrogen were added to the other soil materials in the form of calcium nitrate in the water used for the initial wetting.

Twenty common bermudagrass sprigs (*Cynodon ductylon*) were planted in each container and top dressed. Replanting was done as necessary to maintain uniformity in all containers. The cylinders were wrapped with black polyethylene sheeting to keep light from the roots.

Treatments

Two compaction treatments, two wetting agent treatments and two irrigation programs were superimposed on each of the soil materials for a total of 32 treatments. Each treatment combination was duplicated in randomized block design.

The compaction tests consisted of an untreated check compared with compaction accomplished by placing a circular hardwood plug cut to fit inside the cylinder on top of the grass. A spring-loaded tube requiring about 70 lbs to move it to the end of a stop was pushed down three times on top of the wooden plug. This was done daily for the first five weeks of the experiment and then four times a week for the remaining three weeks of the experiment. On days that water was required, compaction was done before water was added.

The wetting agent treatments consisted of a check without wetting agents and a wetting treatment of the dry soil initially with water containing 3 ppm wetting agent.

The two irrigation programs used were a set calendar schedule and irrigation guided by the tensiometer readings. One-half surface inch of water was applied three times a week under the set irrigation program. Water was applied to the containers receiving tensiometer-guided irrigation only when the soil water suction was between 30 and 40 centibars. If the shallow tensiometer indicated need for water but the lower one didn't, only water sufficient to wet the upper part of the soil column was applied. When the lower tensiometer indicated water need, additional water was applied to reach the lower parts of the container. Water was never added in quantities sufficient to cause drainage from the bottom of the container under the tensiometer-guided irrigation program.

Midway through the experiment, fertilizer was added equivalent to 1 lb N per 1,000 sq ft in the form of $Ca(NO_3)_2$

tion, and Wetting Agents in Turfgrass Management

dissolved in 90 ml of Hoagland's solution. Containers with lignified wood received Hoagland's solution but no nitrogen. The experimental period extended from May 25 to July 20.

Infiltration rate

The infiltration rate was highest in the calcined-clay- and lignified-wood-amended soils, next highest in peat, and lowest in the soils without amendments. The compaction treatment decreased the infiltration rate of peat and unamended soil but had no significant effect on the other two treatments. The wetting-agent treatment increased the infiltration rate of unamended soil, but had no effect on the physically amended soils.

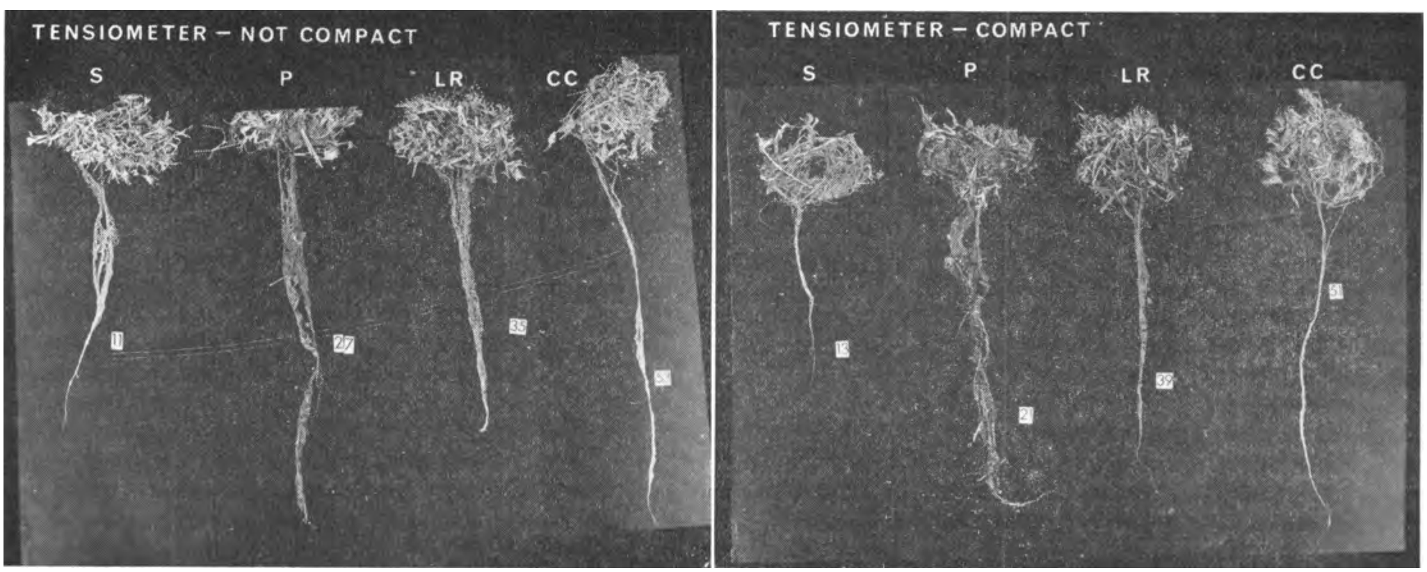
The compaction treatment caused the soil mixes to become compact in this order (from greatest to least): unamended soil, peat, lignified wood, and calcined clay. For each soil material, the compaction was greater when the irrigating was done on a set schedule as compared with the tensiometer-guided irrigation. The wetting agent caused the peat-amended soil to become less compact, but had no effect on the other soil materials.

Evapotranspiration

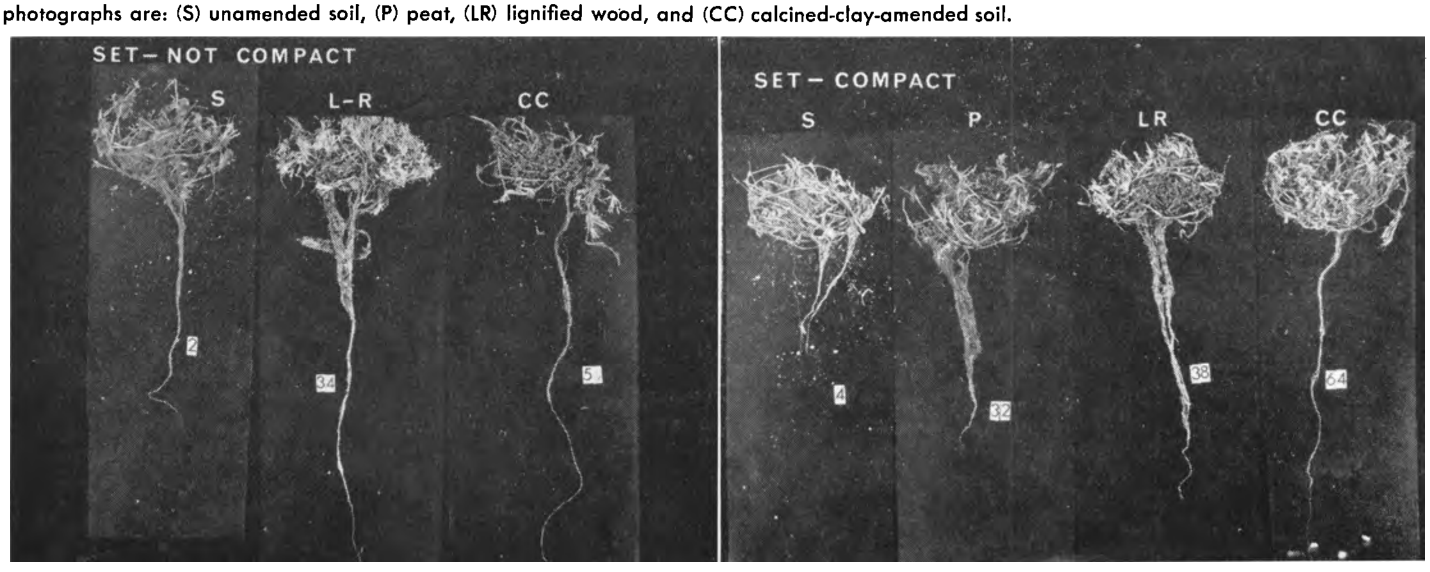
The evapotranspiration was higher under set, as compared with tensiometer-guided, irrigation. This result is probably due to the surface remaining much wetter under set irrigation. The only effect of soil mix was that the evapotranspiration was less in lignified-wood-amended soil than the others when tensiometer-guided irrigation was used. This probably resulted from less top growth under this treatment.

Evapotranspiration was less when the soil mixes were compacted as compared with no compaction. This is also probably due to reduced top growth resulting from soil compaction.

These results closely follow the results on evapotranspiration. The irrigation program had the biggest effect on evapotranspiration and number of irrigations. These results are strictly applicable to the calendar irrigation program adopted,



Typical root systems of grass grown under the various irrigation and compaction treatments in the different soil mixes. The abbreviations on the photographs are: (S) unamended soil, (P) peat, (LR) lignified wood, and (CC) calcined-clay-amended soil.



and the environmental conditions of the experiment. Had a set schedule of once-a-week irrigation, rather than three times a week—or higher environmental evaporative demands—existed, the results could have been different. The set schedule was chosen because it is similar to programs commonly followed in turf irrigation in southern California.

Tensiometers can be installed to guide irrigation so that the soil will not become too dry before watering. Moreover, field experience with turf, citrus, and avocados indicates that the general effect of tensiometer-guided irrigation, as compared with prevailing irrigation programs, is to decrease the amount of water used for irrigation.

Dry weight of clipppings

Measurements of clippings from the first half of the experiment showed top growth was greater when the soil was amended as compared with no amendment, when irrigated on the set program. When irrigation was based on tensiometer records, the lignified-wood-amended and the unamended soil produced less top growth than the other two soil mixes. In comparing the two irrigation programs, there was less top growth on the lignified wood treatment, when watered according to tensiometer records, than the set program. This was in contrast to the other soil materials which had higher average dry weight (although not statistically significant) when irrigated on the tensiometer program. Compaction significantly reduced the top growth as compared with no compaction.

The effect of irrigation programs on top growth over the last half of the experiment was the same as for the first half—except that differences were large enough to be statistically significant. Lignified wood provided the most top growth when much water was used, as under the set irrigation program. When tensiometers were used to guide irrigation, amendment with lignified wood was no better than unamended soil for producing top growth. Of all treatment combinations, peat under tensiometer-guided irrigation produced most top growth.

Whereas compaction treatment affected the top growth during the first half of the experiment, it had no significant effect over the last half.

Wetting agents had no effect on top growth.

Salinity aspects

The electrical conductivity (EC) of the leachate caused by set irrigation is presented as a function of time for the various soil materials in the graph. The electrical conductivity is related to the concentration of salt in the water.

Salts leached

Salts from the unamended, the peat, and the calcined-clay-amended soils were leached out during the first 18 days. The EC thereafter remained fairly constant and equal for these three soil materials. The EC of the leachate from lignified-wood-amended soil was, in general, higher than the others and particularly so over the last part of the experiment. These data suggest that the lignified wood has a source of ions which are slowly released and therefore not immediately removed by leaching. The increase in EC from lignified wood after the twenty-fifth day was probably caused by a change in the weather which, up to that date was fairly cool and cloudy, then became clear and hot. A smaller fraction of the water added came through as leachate and therefore was more concentrated.

The original saturated-soil-extract EC of the various soil mixes was 1.30, 1.97, 2.16, and 4.12 mmho cm^{-1} for unamended soil, calcined clay, peat, and lignified-wood-amended soil respectively. Under tensiometer-guided irrigation there was no leaching so these values represent the approximate salinity of the various soil mixes.

The average pH of the leachate was 7.6, 7.1, 5.9, and 5.2 for the unamended soil, calcined clay, lignified wood, and peat, respectively. The pH of leachates from unamended soil and calcined-clay-amended soil did not change much through the course of the experiment. The leachates from the peat-amended soil during the latter part of the experiment had a higher pH than for the first part of the experiment. The opposite was the case for lignified-wood-amended soil where the higher pH values were measured in the first part of the experiment.

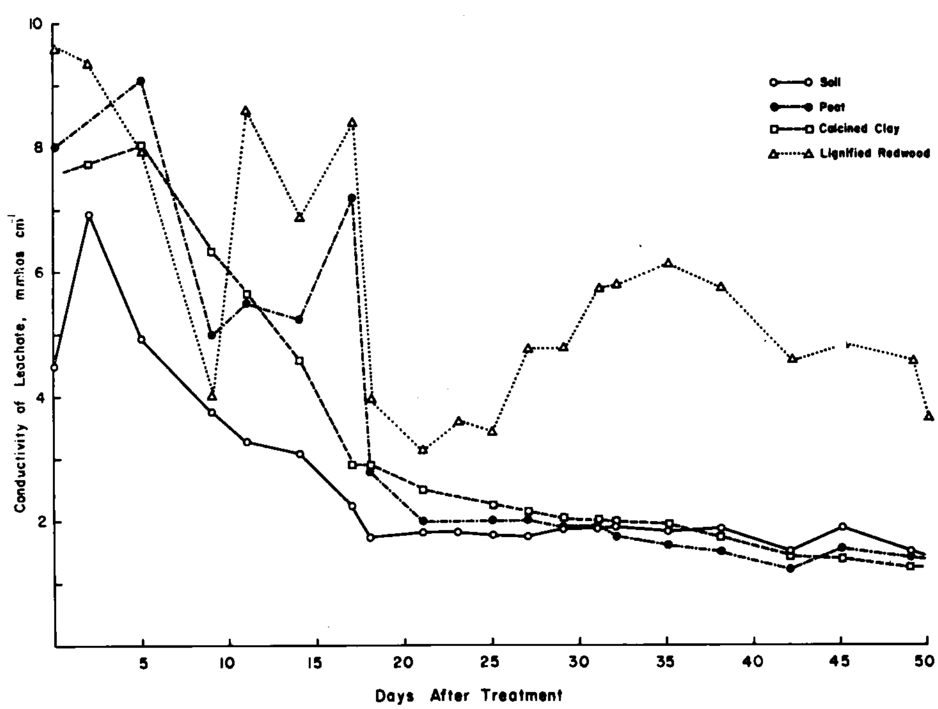
The better top growth of grass grown on lignified-wood-amended soil when the soil was subjected to much leaching—as was the case with set irrigation—is most likely due to the retention and slow release of nutrients (particularly nitrogen). The failure of the grass to grow well on lignified wood under tensiometer-guided irrigation was due to high salinity.

Tissue analysis

The mineral concentrations in the clippings analyzed were influenced by the treatments (except for phosphorus, which was not significantly affected by treatment): the levels of concentration were higher than have been considered as deficient for grass growth, except nitrogen, which was borderline.

The concentration of nitrogen was highest in grass grown in lignified-wood-amended soil. The concentration of nitrogen was lower when the soil materials were irrigated on a set schedule, as com-

ELECTRICAL CONDUCTIVITY OF LEACHATE FROM CONTAINERS IRRIGATED ON SET SCHEDULE AT VARIOUS TIMES AFTER START OF EXPERIMENT



pared with tensiometer-guided irrigation—except for the lignified wood which was not affected by irrigation treatment. The lower concentration of nitrogen in plants grown under set irrigation in soil, peat, and calcined clay was probably because the nitrogen was leached from the soil. The slow release of nitrogen from lignified wood kept adequate nitrogen available for the plant in spite of leaching. These results help explain the good growth of grass on lignified-wood-amended soil when irrigated under the set irrigation program.

ODR and root growth

The measured oxygen diffusion rate (ODR) values from containers receiving irrigation based upon tensiometer readings were all higher than 0.40 $\mu g\ cm^{-2} min^{-1}$. These values are not expected to be deficient for plant growth. It is possible that, if ODR measurements had been taken daily, ODR might have been in the deficient range for certain treatments for a period of time after irrigation.

In general, the ODR values under set irrigation were lowest in the unamended soil. Peat-amended soil was next lowest with the other two amendments providing an environment of fairly high ODR. Oxygen diffusion rate values measured in the noncompacted soil materials were higher than in the compacted unamended soil and peat-amended soil. The ODR values in the other amended soils were not greatly affected by compaction. The root growth was, in general, correlated with ODR measurements. The lower ODR limit for root growth was about 0.15 $\mu g\ cm^{-2} min^{-1}$.

The photographs illustrate the roots grown in the various soil mixes for various compaction and irrigation treatments. It can be noted that the lignified wood and calcined clay tended to eliminate the effects of overirrigation and compaction on root growth. Tensiometer-guided irrigation tended to reduce the ill effects of compaction on root growth in unamended soil.

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Comparison of Two Soil Amendments for Carnation Production

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CARNATION GROWERS utilize any of several bulky organic materials for amending greenhouse soils to improve aeration, drainage, and moisture retention. Redwood sawdust has been the standard material used in San Diego County. The trial reported here compared plant growth and flower production of carnations grown with two soil amendments—10 and 20% by volume of Redwood sawdust, and 10 and 20% by volume of processed lignin particles, replicated three times. They were conducted at Hillside Floral Company, Encinitas, and the amendents were incorporated in a Carlsbad sandy loam in raised benches prior to planting. The greenhouse soil had not been previously amended.

Each series of replications was planted to a Sims carnation variety (red, pink, white) in mid-July, 1963. The plant spacing was 3.15 plants per sq ft of bench area. First blooms were cut in late October. Daily harvest records of blooms were recorded for each treatment for one year. Grades were not recorded. Periodic checks were made for differences in growth and bloom quality.

Based on the conditions of this experiment, a 20% addition of processed lignin particles to a previously unamended soil, produced about 3½ additional carnation flowers per sq ft of bench in 12 months of flower production as shown below:

FLOWER PRODUCTION, AVERAGE OF THREE REPLICATES FOR ONE YEAR

Treatment	Flowers per sq ft of bench	Flowers per plant
Lignin 20%	54.80*	17.14
Lignin 10%	51.50	16.45
Redwood 20%	51.23	16.38
Redwood 10%	51.02	16.13

*Significantly different (5% level).

If this difference could be obtained in commercial practice, a 20% addition of processed lignin particles would produce an economic gain despite its higher initial cost (see table).

From observation as well as data recorded, it appeared that the gain in production with addition of 20% lignin was due to a more rapid early growth of the plants and more rapid crop cycling. Flowering of the first crop was about two weeks early where the 20% lignin treatments were applied. It was also apparent that a 10% lignin addition was insufficient to produce a measurable production response. Redwood at 10% and 20%, and lignin at 10% were statistically the same.

Soil amending is but one of many cultural factors affecting flower production. Response may vary considerably depending on the type of soil to be amended. Economic extrapolations are particularly difficult in flower-producing enterprises because of the many differences in grower practices, such as plant spacing variations, percentage of greenhouse area in production, the area involved in replanting, the time of year that flowers are produced, average price received, and flower grades. Growers interested in comparing redwood sawdust and processed lignin particles for amending soils for carnation production should compare the two materials, each at 20% by volume of soil, on a trial basis. Accurate flower harvest records should be kept with occasional quality grade-outs. Additional data will also be needed to determine relative responses in the second year of production.

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COST OF PRODUCTION ESTIMATE PER SQ FT OF BENCH

	Redwood 10%	Redwood 20%	Lignin 10%	Lignin 20%
Per sq ft				
Basic costs[a]	$1.0000	$1.0000	$1.0000	$1.0000
Soil amendments[b]	.0037	.0074	.0222	.0444
Flower handling[c]	.5102	.5123	.5150	.5480
	$1.5139	$1.5197	$1.5372	$1.5924
Per flower Cost (cents)	2.9673¢	2.9664¢	2.9849¢	2.9058¢

[a] Based on a 1958 Carnation Cost Study, San Diego County, Agricultural Extension Service, University of California.

[b] Based on costs of $2.00 per cu yd for Redwood sawdust and $12.00 per cu yd for processed lignin particles.

[c] Flower handling is that portion of production costs, such as disbudding, banding, cutting, grading, and bunching, that is accrued per flower, and increases with the number produced.