GREENKEEPERS FIND IT DIFFICULT TO
maintain a uniform turf area of
desirable grass species on established
bowling and putting greens. These types
turf often are subjected to heavy foot
traffic when soils are wet. Their specific
use also requires that they be moved
closely at frequent intervals. In time, peri-
odic top-dressing causes thatch buildup
and stratification of soil layers. Water
penetration is typically poor, and low in-
filtration rates make it difficult to irrigate
properly. Such soils tend to remain near
saturation in the shallow soil layers.

These conditions favor the growth of
annual grasses rather than the desirable
perennial grass species. The desirable
grasses often succumb to disease, die out,
or lose vigor. Weedy annuals, particularly
Poa annua, subsequently invade the turf
and often replace large portions of it. Poa
annua does not withstand traffic and dis-
cease. The turf tends to lose color and be-
come thin or bald, particularly during
warm weather.

If the turf becomes inadequate to serve
the purpose for which it was planted, one
of several procedures is generally followed
to restore the grass to a playable condi-
tion. The most costly is to remove the old
soil, replace or modify the soil, and estab-
lish a new turf. Another approach is to
renew the old turf by cultivation, fumi-
gation, and reseeding. Deep verticutting
and overseeding also are used. If the
green is not completely unplayable, a
change in management practices, such as
improved fertilization, proper use of cul-
tural equipment, better water manage-
ment, and rescheduling of play, may be
all that is necessary to improve the condi-
tion of the turf.

Vertical mulching is a different ap-
proach to turf renovation which recently
has been given consideration. This con-
ists of removing 1-inch cores of soil to a
depth of about 6 inches at relatively close
spacings. The holes then are back-filled
with a stable soil mix, usually consisting
of fine sand and organic matter. This
report summarizes tests undertaken re-
cently to further evaluate this practice.

The site selected for the study was the
Henderson Bowling Green, a 40-year-old
grass maintained by the City of Berkeley
Park Department. The original grass was
Seaside bent, but the present turf is pre-
dominantly Poa annua. The original soil
mixture was a 12-inch layer of Dublin
clay loam and coarse sand placed over a
crushed rock base. Table 1 shows the
textural analysis of the top 6 inches of
soil.

Topdressing over the years has strati-
fied this soil with alternate layers of
organic matter and coarse sand. There is
a layer of coarse sand about 1/2-inch thick
at a depth of about 3 1/2 inches throughout
the green. The origin of this layer is not
known. The stratification of the soil can
be seen in the photo of soil profile from
the test putting green.

An area of turf 12 x 120 ft, on the east
side of the bowling green was used for
this experiment. Two adjacent strips of
20 plots, each 5 x 5 ft square, were marked
out, and the following treatments were
applied on April 9 and 10, 1964: (1) no


TABLE 1. PERCENTAGES OF ORGANIC MATTER CONTENT
AND MECHANICAL ANALYSIS OF MINERAL FRACTION OF TOP 6 INCHES OF SOIL
(Weight basis, average of three composite samples)

<table>
<thead>
<tr>
<th>Depth</th>
<th>Organic matter</th>
<th>Coarse sand</th>
<th>Fine sand</th>
<th>Silt</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>20.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-3</td>
<td>12.3</td>
<td>16.6</td>
<td>51.5</td>
<td>11.3</td>
<td>9.8</td>
</tr>
<tr>
<td>3-4</td>
<td>5.6</td>
<td>18.9</td>
<td>45.3</td>
<td>11.8</td>
<td>6.9</td>
</tr>
<tr>
<td>4-5</td>
<td>4.6</td>
<td>18.2</td>
<td>51.9</td>
<td>18.7</td>
<td>11.2</td>
</tr>
<tr>
<td>5-6</td>
<td>6.0</td>
<td>12.9</td>
<td>24.1</td>
<td>29.1</td>
<td>22.9</td>
</tr>
<tr>
<td>MAT</td>
<td>12.6</td>
<td>17.8</td>
<td>35.0</td>
<td>18.2</td>
<td>9.0</td>
</tr>
</tbody>
</table>

* Organic matter fraction removed before making mechanical analysis.

† Composite of 2-inch-deep cores of soil removed by a mechanical aerifier.
Water was withheld from the test area for three days. Two infiltration measurements were taken in each plot in one strip. A depth of nine inches of water was placed in the ring infiltrometers. Measurements of the drop in water surface were taken at 10-minute intervals over a period of one hour. The accumulated infiltration after one hour is shown in table 4.

**Table 4. Accumulated Infiltration in Inches in One Hour on September 29-30**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rep. III</td>
<td>.10</td>
<td>.16</td>
<td>.28</td>
<td>.16</td>
<td>.17</td>
</tr>
<tr>
<td>Rep. IV</td>
<td>.17</td>
<td>.20</td>
<td>.44</td>
<td>.29</td>
<td>.16</td>
</tr>
<tr>
<td>Average</td>
<td>.16</td>
<td>.16</td>
<td>.41</td>
<td>.24</td>
<td>.16</td>
</tr>
</tbody>
</table>

Results

Analysis of the data indicates that vertical mulching improved infiltration, and that this effect was linear with closeness of spacing. When holes were spaced as far as 9 inches apart, the infiltration rate was no better than that of the check. There was no measurable effect on infiltration from the mechanical aeration. This lack of response was probably related to the limited depth of soil penetrated by the aerifier. The infiltration rates on all treatments were considerably lower than at the time of previous tests. This decrease in infiltration rates was partly due to depth of water in the infiltrometers. However, supplementary tests, using 9-inch depths of water, increased infiltration rates only about 20% as compared to the 1 1/2-inch depths used in this test.

Low infiltration rates of water into soils are one of the major problems on bowling and putting greens. Soil profile through the test putting green with vertical mulch holes on 3-inch centers showing vigorous, healthy root system. A portion of the backfill material has been washed out of these holes to better illustrate the root growth. This soil profile also shows the stratification or layering which is found in most all old bowling and putting greens. This layering is due to topdressing with materials different from the original soil mix.
turf areas subjected to heavy use. Vertical mulching has been proposed as a means of overcoming this problem.

The results of this study indicate that closely spaced vertical mulch holes will increase infiltration rates. This increase is linearly related to the closeness of spacing of the holes. In these tests, the infiltration rates on all plots decreased as the season progressed. This decrease is a characteristic of most soils in California. In late September, the rates were less than \( \frac{1}{2} \) inch per hour for the 3-inch spaced holes; and less than \( \frac{1}{4} \) inch per hour for the widely spaced holes, mechanically aerified plots, and nontreated areas. Infiltration rates were found to be quite variable even within a small area. This points out the desirability of having a large number of replicated infiltration measurements in studies of this type.

**Vigorous growth**

Vertical mulching or mechanical aerifying did not increase the percentage of bentgrass over *Poa annua* as indicated by visual observation. Vertical mulch holes and mechanically aerified holes, back-filled with sand and organic matter, provided an excellent environment for vigorous growth of grass roots.

The soil on which these tests were conducted was a 12-inch layer of clay loam and sand mix overlying a crushed rock base. The vertical mulch holes did not penetrate the full depth of the soil material. Different results might be expected where the vertical mulch holes penetrate through a dense or stratified surface layer into a more pervious soil beneath.

Good growth of any plant is related to several interdependent factors. Although close-spaced vertical mulching does significantly increase water infiltration, this practice by itself does not appear to be the complete solution to the problem of improving old greens. Further information on the interrelationship between vertical mulching and other cultural practices is needed.

It is quite possible that a better irrigation system coupled with vertical mulching would take better advantage of the improved root environment provided by vertical mulch holes filled with an improved soil mix. Further studies are in progress.

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**Pasture and greenchop performance comparisons . . .**

**PIPER SUDANGRASS AND SUDAN HYBRIDS UNDER IRRIGATION**

D. C. SUMNER • V. L. MARBLE • E. J. GREGORY

Many trials comparing the yielding ability of some of the sudan hybrids with Piper sudangrass have failed to show any significant differences in pasture production when based upon dry matter produced.

Greencrop operators in California utilize those summer annuals in every stage of growth from near 20 inches in height to near maturity. The height at which these crops are harvested as greencrop depends upon how often the stand must be recut to keep material moving to the feeding operations. The data presented here suggests that if greencrop operators harvest their crop at about 5 to 6 ft or less in height, there is little or no advantage in using hybrids. If, however, greencropping is confined to plant material, 7, 8, or 9 ft in height, there is a definite yield advantage from using the excellent sudan hybrids.

A **GRICULTURE** is being offered a number of hybrid varieties of sudangrass for use as annual summer pasture and greencrop. These hybrids originate from crosses between two sudangrass varieties, sudangrass and grain sorghums, forage sorghums, or sorgos. These cultivars produce well and provide feed of good quality. The sorghum-sudan hybrids generally retain some characteristics of both parents; most being thick stemmed, late maturing, and tall.

For the past three years Piper sudangrass and cultivars representing some of the hybrid types were tested in comparative yield trials under irrigation at Davis. Piper sudangrass was used as the standard in these trials—not because it is more productive than other sudangrass, but it is popular and widely used in California.

In 1961, Piper sudangrass, SX-11 (grain sorghum × sudangrass), and NK-300 (a hybrid forage sorghum normally used for silage) were tested for pasture and greencrop yield. Pasture conditions were simulated by harvesting these cultivars when each reached 2 ft in height. Greencrop conditions were simulated by harvesting each variety at the 50% late-boot stage (when 50% of booted tillers have heads already emerged or starting to emerge; could also be designated as very early heading).

Pasture trials showed a higher percentage of moisture and protein for SX-11 and NK-300 at the same height as Piper sudan, while at the greencrop stage of development—when the cultivars were near the same stage of maturity—there was less difference in protein values. However, the hybrids still contained a greater percentage of moisture. When used as pasture, there was no significant difference in dry matter yield between a sudangrass, a sorghum-sudan hybrid, and a hybrid forage sorghum. Under greencrop conditions, the hybrid forage sorghum was significantly lower yielding than the other two. This can be attributed to a slower recovery rate after harvest, slower growth prior to the last cutting.

**TABLE 1. COMPARISON OF PASTURE AND GREENCHOP DRY MATTER AND GREEN WEIGHT YIELDS OF SUDANGRASS, A SORGHUM-SUDANGRASS HYBRID, AND A SUDAN HYBRID—1962**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Dry Matter (lb/acre)</th>
<th>Total Green Weight (lb/acre)</th>
<th>% Ave. Moisture</th>
<th>Ave. Plant Height (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piper</td>
<td>9.03</td>
<td>63.07</td>
<td>84.83</td>
<td>36.2</td>
</tr>
<tr>
<td>SX-11</td>
<td>9.55</td>
<td>70.61</td>
<td>86.42</td>
<td>27.8</td>
</tr>
<tr>
<td>Sub-1</td>
<td>9.15</td>
<td>66.79</td>
<td>86.76</td>
<td>26.6</td>
</tr>
<tr>
<td>LSD (0.01)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>LSD (.05)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>LSD (.1)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

**GREENCHOP**

Harvested when Piper reached 50% late bootage

<table>
<thead>
<tr>
<th>Variety</th>
<th>Dry Matter (lb/acre)</th>
<th>Total Green Weight (lb/acre)</th>
<th>% Ave. Moisture</th>
<th>Ave. Plant Height (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piper</td>
<td>56.36</td>
<td>79.24</td>
<td>12.06</td>
<td>54.7</td>
</tr>
<tr>
<td>SX-11</td>
<td>77.49</td>
<td>85.06</td>
<td>11.58</td>
<td>50.3</td>
</tr>
<tr>
<td>Sub-1</td>
<td>65.31</td>
<td>84.49</td>
<td>10.73</td>
<td>47.6</td>
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<tr>
<td>LSD (0.01)</td>
<td>4.45</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>LSD (.05)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>LSD (.1)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>