In March, 1950, a sample lot of seed used for this test gave a germination of 82.33 per cent. Following are the results:

Treatment		Per Cent Germination — Average of Three Replications								
		4/10/50	7/10/50	11/20/50	2/1/51	6/11/51	10/2/51	7/29/52	2/2/53	2/1/55
5°C.	A.	81.3	76.3	81.0	75.6	70.0	68.1	12.6	48.3	12.6
	B.	78.0	78.0	75.6	75.3	73.0	71.0	13.3	32.0	13.6
	C.	80.3	75.7	79.0	73.3	69.0	67.3	14.3	25.3	15.0
15°C.	A.	75.0	60.3	64.6	38.3	13.0	12.0	00.7	00.3	00.0
	B.	76.0	72.7	77.6	30.0	70.0	55.0	43.3	33.3	18.0
	C.	76.0	75.0	74.6	76.3	70.7	47.0	38.3	37.0	14.3
25°C.	A.	79.6	73.0	77.0	67.0	60.0	52.7	22.3	24.0	01.3
	B.	77.3	70.7	84.6	72.3	61.0	49.0	35.3	33.3	06.3
	C.	74.6	70.0	82.3	69.6	63.7	61.0	26.0	35.0	20.0

A = unsealed vials.
B = vials sealed with paraffin.
C = $CaCl_2$ added befire sealing vials with paraffin.

Statistical analysis performed on the foregoing data indicates significance for all the following sources of variation: temperature, condition of storage, temperature x condition of storage, date counts made, and date counts made x temperature. The only source of variation that did not show significance was date counts made x condition of storage.

Seeds stored at 5° centrigrade held up slightly better than seeds stored at other temperatures. However, all seeds dropped considerably in germination in the third year of tests.

The greatest source of variation arose from the failure of the unsealed vials stored at 15° to hold up for as long as one year. This cannot be explained except to say that perhaps storage conditions were at fault. Other tests at 15° performed rather consistently except for the 2/1/51 sampling date of the sealed vials.

At the 25° temperature, only the seed stored with $CaCl_2$ compared favorably with samples stored at the lower temperatures after five years.

Under the conditions of storage set forth in this experiment, common *Zoysia japonica* seed reduces sharply in germination after two and one-half years.

[1] *Effects of Strain Differences,, Seed Treatment, and Planting Depth on Seed Germination of Zoysia Spp. Agronomy Journal* 40:8 (1948).
[2] *Verret; page 33 Growth of Plants" by William Crocker.*
Statistical analysis performed by Dr. E. J. Koch, U. S. Department of Agriculture, Beltsville, Md.

WHEN YOU BUILD A PUTTING GREEN MAKE SURE THE SOIL MIXTURE IS A GOOD ONE

By MARVIN H. FERGUSON

USGA Green Section Southwestern Director and National Research Coordinator

THERE are many factors one must consider in the building of a putting green. Among these are location, slope, exposure, design, contour, water outlets, soil mixture, type of grass, and many others. Probably no other factor is as important in building a putting green as is the soil mixture.

The soil mixture is important to the ultimate welfare of the putting green because it must be of such a nature that it will drain quickly, that it will resist compaction, and that it will be resilient enough to hold a properly played shot and yet not so spongy that it will hold a shot played poorly. The surface of the putting green should resist deep pitting when balls are played to it. Moisture content of the soil as well as the amount of turf present affects the type of putting that will occur.

The foregoing requirements of a putting green soil are peculiar requirements but in addition there are the basic requirements that any soil must provide to sup-

port plant growth. There are normally five functions of an agricultural soil. It provides to plants: support, nutrients, oxygen, water and a favorable temperature. All of these attributes of a soil can be altered to varying degrees by the management. The ideal soil is one which would meet all the needs of plant growth; those special requirements imposed by putting green maintenance, and which would resist the ill effects of poor management.

No soil will do this but putting greens are valuable enough that we can afford to build a synthetic soil, and we must come as close to the ideal as possible. We know that we must sacrifice nutrient and water supplying power of the soil in order to meet other requirements such as rapid drainage, compaction resistance and aeration.

No "Ideal" Mixture

Where do we reach the point at which the various considerations are most nearly in balance? Much research has been done on the subject and no one has yet proposed an "ideal" soil mixture for putting greens. However, we must have putting greens in the meantime. Many are rebuilt annually and each builder has to make a decision concerning the properties of his mixture.

A putting green builder must work with materials available to him within a reasonable distance. Most builders use a mixture of sand, soil and peat. If coarse, sharp sand and reed and sedge peat are used there will be little variation in the way they will behave. Very often, however, little is known about the soil which is incorporated into a mixture. It is important to know the percentages of clay, silt, and sand which make up a soil.

Studies are continuing and it is likely that our ideas will change as our knowledge increases. At the present time, however, it is believed that there is sufficint information available to permit a better job of building putting greens than is presently being done in many cases.

Studies at Oklahoma A. & M. College and elsewhere indicate that 20% of peat, by volume, is the maximum that ever should be used. Fifteen percent is probably better. From 5% to 8% of clay is sufficient to permit soils to be fairly effective suppliers of nutrients. When the clay content of a soil rises above 10% it tends to become plastic and the soil compacts readily. Silt and very fine sand particles are large enough that they do not form aggregates as readily as clay particles, yet they are so small that they tend to clog pore spaces and drainageways among sand particles and soil aggregates. Therefore, we should like to have as low a silt and very fine sand content as possible in soils.

Table 1 at the conclusion of this article shows the percentages of the various sizes of soil particles found in three different soil types. The sandy loam soil described in this table approaches the type generally thought to be most desirable for putting greens. If 15% of peat or other slowly decomposable organic matter were added to this sandy loam, one would have a mixture containing 56.1% coarse sand, 19.89% fine sand and silt, 7.23% clay, and 15% organic matter.

If we look at the second soil type, a loam, we see that the clay content is considerably higher. In order that this soil should supply from 5% to 8% of clay we would need to mix it in the proportion of approximately 15% peat, 35% soil, and 50% coarse sand. Such a mixture would then show an analysis of approximately 59.49% coarse sand, 17.68% fine sand and silt, 6.75% clay and 15% organic matter.

If a putting green were to be built using heavy clay as the soil component, one would only be able to use about 10% of

the soil, 15% peat and 75% of a coarse sand. Such a mixture would consist of 6.58% clay, 75.09% coarse sand, 2.85% fine sand and silt and 15% organic matter. This mixture will come very near to supplying all the needs of a putting green soil.

Now let us look at these three mixtures together in Table 2. We find that they are similar in many respects. Perhaps the most important consideration is that the organic matter and clay contents be similar. The clay and organic matter provides great surface area to hold moisture and nutrients. A small variation in these components can produce a very great effect on the behavior of the finished mixture. These three mixtures appear to have similar qualities, even though of the original soils 85% soil went into the first mixture; 35% into the second; and 10% into the third.

Drainage and Aeration

We cannot be sure, however, that these soils will be equally good in a putting green. The silt and very fine sand content of soil No. 1 is 19.89% while that of No. 2 is 17.68%. Contrast these figures with soil No. 3, which has a silt and very fine sand content of 2.85%. Number 3 mixture will have adequate nutrient and moisture supplying power and it will also drain promptly. Good drainage and ample aeration go together. It is an excellent soil.

Mixtures No. 1 and No. 2 have good nutrient and water supplying ability but their drainage and aeration characteristics probably are not so good because of the presence of relatively large amounts of very fine sand and silt. It would be necessary to reduce the peat content a great deal to insure adequate water infiltration and percolation rates.

Thus we may see that it is important to get a mechanical analysis of the soil one intends to use, and to modify it by the addition of sand and organic matter according to the needs determined from the analysis. Relatively small deviations from the optimum mixture may be critical.

All the foregoing discussion has concerned the matter of obtaining a proper soil mixture. It is also important that a good foundation be prepared before the soil is placed on the putting green. The following steps will insure that the subgrade and drainage will be adequate:

1. Contour the subgrade just as the finished surface will be contoured. The base will be about 14 inches below the putting surface.

2. Lay tile in a suitable pattern on the subgrade in broad shallow trenches, using the soil from these trenches to create a slope between tiles, so that water will drain to them readily.

3. Place a layer of clean gravel (approximately 1/4" aggregate) over the tile, covering it completely. This layer of gravel will average 3" in thickness though it will be about 5" thick over the trenches in which the tile is laid.

4. Place a layer of coarse sand, approximately 1½" thick over the gravel. This sand will filter into the gravel to some extent but it will provide a zone of intermediate texture which will prevent the

COMING EVENTS

1955

Dec. 7-9:
Oklahoma Turfgrass Conference, Oklahoma A. & M. College, Stillwater, Okla. Dr. Wayne W. Huffine.

Dec. 12-14:
Texas Turfgrass Conference, Texas A. & M. College, College Station, Texas. Dr. Ethan C. Holt.

1956

Jan. 16-20:
Rutgers One-Week Turf Conference, Rutgers University, New Brunswick, N. J. Dr. Ralph E. Engel.

Jan. 17-18:
Mid-Atlantic Annual Turf Conference, Lord Baltimore Hotel, Baltimore, Md. Dr. E. N. Cory.

Feb. 5-10:
Golf Course Superintendents 27th National Turfgrass Conference and Show, Long Beach, Cal. Agar M. Brown.

February 13-14:
Third Arizona Turfgrass Conference, University of Arizona, Tucson, Ariz. Joseph S. Folkner.

Feb. 20-23:
Penn State Turf Conference, Pennsylvania State College, State College, Pa. Prof. H. B. Musser.

topsoil particles from being washed down into the gravel.

5. The topsoil mixture should be mixed off the green. A layer 10" to 12" thick should be applied. After settling, the topsoil layer should be thick enough to allow a cup to be cut out without cutting into the sand layer below. It is important that the top soil mixture be thoroughly firm before the grass is planted. One method of doing this is by tramping it under foot until the soil is firm. This method is called "footing." After tramping the entire surface of the green it will be rather uneven and rough. It should be raked smooth and then the "footing" process should be repeated. When the soil is as firm as one is able to get it using this process it should be watered sufficiently to settle the surface and so that one may avoid any pockets or low spots that need to be filled.

6. Only after the surface is thoroughly firm and smooth should grass be planted. Either seed or stolons may be used. The improved strains which are nearly all planted vegetatively have been shown to be much more resistant to many of the putting green troubles such as disease and weed infestation than are the seeded types. After one goes to all the trouble necessary to build a putting green properly, it seems worthwhile to obtain the best grass available for planting.

As our knowledge of soils increases it is quite likely that we will find better mixtures and better building methods. At the present time we feel that the suggestions offered herein will permit the building of much better putting greens than many of those which have been built in the past.

TABLE 1

Classification of Soil Particles According to System of International Society of Soil Science, and Mechanical Analysis of Three Soils*

Fraction	*Diameter millimeters*	*Sandy loam, per cent*	*Loam, per cent*	*Heavy clay, per cent*
Coarse sand	2.00-0.20	66.6	27.1	0.9
Fine sand	0.20-0.02	17.8	30.3	7.1
Silt	0.02-0.002	5.6	20.2	21.4
Clay	Below 0.002	8.5	19.3	65.8

**From Lyon and Buckman, 4th ed., p. 43.*

NOTE: *The figures do not add up to 100%. It is assumed that soil materials, such as gravel particles, made up the soil fraction and that these were not included in the analysis.*

TABLE 2

Percentages of Various Components in Putting Green Soil Mixtures Using Sand and Peat in Combination with Soil Types Shown in Table 1.

No.	*Mixture*		*Coarse Sand* (2.00-0.20 *mm.*)	*Very fine Sand and Silt* (0.20-.002 *mm.*)	*Clay*	*O.M.*
1	Sandy Loam Peat	85% 15%	56.1	19.89	7.23	15
2	Loam Peat Coarse Sand	35% 15% 50%	59.49	17.68	6.75	15
3	Heavy Clay Peat Coarse Sand	10% 15% 75%	75.09	2.85	6.58	15

Superintendent Chats With Champion

Elmer Border, superintendent at the Olympic Country Club, in San Francisco (left), chats with Jack Fleck, the Open Champion, as they inspect the Open Trophy. Elmer did a fine job in preparing the course for the 1955 Open Championship. He gives credit to members of the various committees for excellent teamwork and says they were a great help to him.

SAND IMPORTANT IN TOPDRESSING MATERIAL

By CHARLES K. HALLOWELL

USGA Green Section Mid-Atlantic Director

THERE may be a difference of opinion about topdressing greens, but when topdressing is used there is full agreement that the soil mixture be only the best. Plant growers always want a light, well-drained soil having a liberal amount of good organic material. It is sharp sand that lightens soil and makes it easy to work the material in and around the grass.

Soils high in sand not only drain readily but are less likely to bake. Such soils are less subject to compaction.

The reasons for applying topdressing on greens are to level the putting surface, to provide fresh material for the stems of the grass and often to improve the existing soil. The topdressing material, to be effec-