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Sand Layer
Not Always Necessary

USGA

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Cover Photo:

Second hole on second nine at Montclair Golf Club, New Jersey, in process of being built to USGA Green Section specifications.

Photograph by Rees L. Jones, Golf Course Architect

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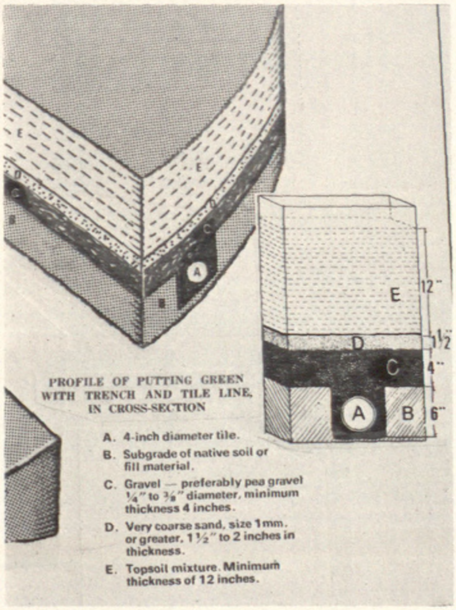
A GREEN SECTION RESEARCH PROJECT

The Necessity of the Two-Inch Sand Layer In Greens Construction[1]

by DR. K. W. BROWN, J. C. THOMAS and DR. A. ALMODARES[2]

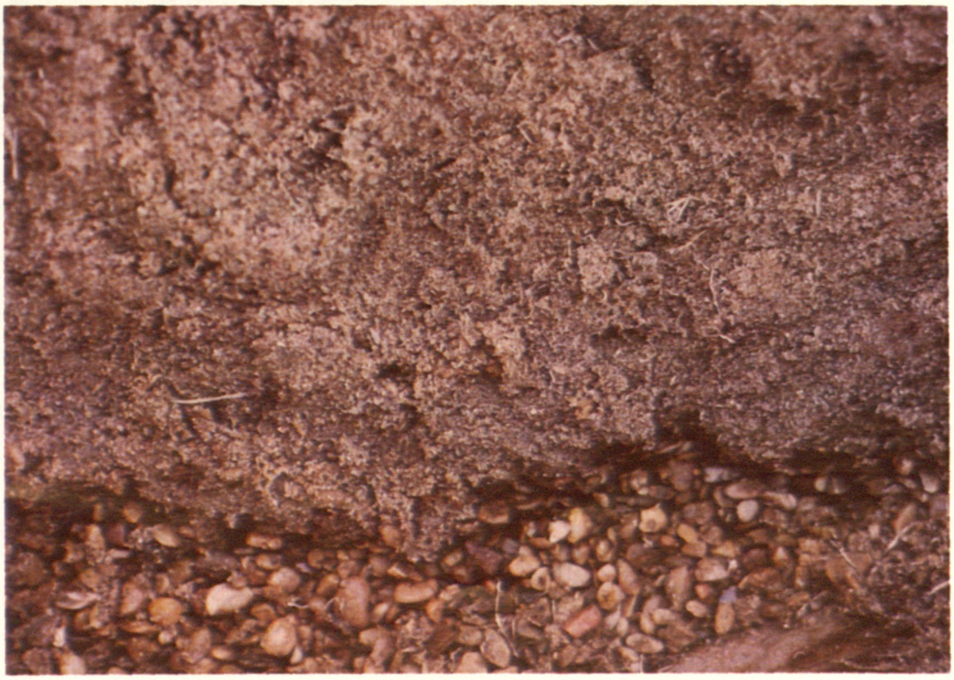
THE USGA GREEN Section, in 1960 and 1973, published specifications for putting green construction which recommend construction in layers. The bottom layer, overlying the subgrade, consists of four inches of pea gravel around a drain tile to insure adequate drainage. A two-inch middle layer of coarse sand is used over the gravel to prevent the soil particles from migrating downward into the gravel and blocking the drain. The 12-inch upper layer usually consists of a mixture of sand, soil, and organic matter and results in the establishment of a perched reservoir of water. The construction of the two-inch sand layer is difficult and expensive, and therefore many seek to omit it. This research was undertaken to determine the effect of the sand layer on the migration of sand and soil particles into the gravel layer.

This work, under the sponsorship of the USGA Green Section, consisted of field and greenhouse phases. Particle migration was assessed in the field in greens which had been installed eight years earlier (Brown and Duble, 1974). Briefly, each of these 21 greens measured 10 feet to a side, hydrologically isolated from one another, equipped with gravel drainage systems and constructed on a raised subgrade to allow for leachate collection. Mixtures used in the field experiment included one replication of 100 percent fine sand, four replications of 90 percent fine sand and 10 percent peat; four replications of 85 percent fine sand, 5 percent soil and 10 percent peat over a two-inch sand layer; four replications of 85 percent fine sand, 5 percent soil and 10 percent peat without a sand layer; four replications of 80 percent fine sand, 10 percent soil and 10 percent peat; and four replications of 100 percent sandy loam soil, two of



(Left) The sand layer involved is the "D" layer in the profile shown.

(Below) Figure 1. Photograph of the lower portion of a field green profile composed of 85% sand, 10% peat and 5% soil directly over pea gravel.



[1]Contribution of Texas Agricultural Experiment Station, College Station, Texas. This work was supported in part by a grant from the USGA Green Section.

[2]Associate Professor, Research Associate, and Research Associate, respectively, Soil and Crop Sciences Department, Texas A&M University.

TABLE 1
Gravel, Sand, Silt and Clay Contents of Samples from Field Greens

Topmix (Sand-Peat-Soil)	Section	% Gravel	% Sand	% Silt	% Clay	% Total Silt & Clay
85-10-5	Topmix	0.8	95.7	2.2a*	1.3a	3.5
with sand	0-2" above sand	1.3	95.2	2.2a	1.3a	3.5
layer	Sand	1.5	95.6	1.8	1.1	2.9
	Gravel	96.7	2.8	—	—	0.5
85-10-5	Topmix	2.0	93.9	2.5a*	1.6a	4.1
without sand	0-2" above gravel	2.2	93.2	2.4a	2.2a	4.6
layer	Gravel	95.3	3.9	—	—	0.8
100-0-0	Topmix	0.9	96.3	2.4	1.4	2.8
without sand	0-2" above gravel	0.3	96.2	2.5	1.0	3.5
layer	Gravel	93.9	4.1	—	—	2.0
90-10-0	Topmix	0.2	95.6	2.5	1.7	4.2
without sand	0-2" above gravel	0.9	96.2	5.0	1.9	6.9
layer	Gravel	94.4	4.8	—	—	0.8
80-10-10	Topmix	1.2	94.4	2.9	1.5	4.4
without sand	0-2" above gravel	1.3	91.8	4.4	2.5	6.9
layer	Gravel	95.5	3.8	—	—	0.9
0-0-100	Topmix	0.0	82.0	15.0	3.0	18.0
with sand	0-2" above sand	0.0	82.4	15.0	2.6	17.6
layer	Sand	0.7	96.8	1.5	1.0	2.5
	Gravel	96.9	2.4	—	—	0.7
0-0-100	Topmix	6.8	80.8	15.2	3.2	18.4
without sand	0-2" above gravel	13.7	71.6	12.0	2.7	14.7
layer	Gravel	92.9	4.9	—	—	2.2

*Values in a given column of a given treatment followed by the same letter do not differ significantly at the 5% level.

which were directly over gravel and two of which were over a two-inch sand layer. Of the mixtures used, the 85-10-5 and 80-10-10 mixtures would be considered USGA mixes. The pure sand and 90-10 sand-peat mixes were too deficient in water retention to be considered USGA mixes. All plots were planted to Tifdwarf bermudagrass. To assess the particle migration, six-inch diameter holes were dug in the greens down to the gravel base. Samples were taken of the gravel, two-inch sand layer if present, the zero to two inches of topmix immediately above the gravel or sand layer, and a composite sample of the remaining top mixture. All samples were analyzed for sand, silt and clay contents.

THE RESULTS FROM plots constructed with 85-10-5, 90-10-0 and 80-10-10 sand-peat-soil mixtures in the absence of a sand layer indicate that there was no particle migration into the gravel drainage layer. Slight accumulation of about 2 percent total silt and clay was measured in the gravel below

TABLE 2
Physical Properties of the Three Sands and Two Gravels

Sand	Gravel > 2mm %	Total Sand .05-2mm %	Silt .002-.05mm %	Clay < .002mm %	SAND FRACTIONS: Very Coarse 1-2mm %	Coarse 0.5-1mm %	Medium 0.25-5mm %	Fine 0.25-.5mm %	Very Fine 0.05-.1mm %
A	0.0	96.2	1.9	1.9	5.2	23.4	50.6	14.8	2.2
B	0.1	98.1	0.3	1.5	0.2	5.8	66.8	22.9	2.4
C	1.5	96.7	2.9	0.4	16.6	27.3	39.2	11.3	1.8

Gravel	>12.7mm	12.7-9.5mm	9.5-6.35mm	6.35-4.0mm	4.0-2.0mm	> 2.0mm
Pea	0.0	0.5	2.1	64.5	30.1	2.9
⅜"	13.4	48.5	24.9	13.0	0.0	0.1

TABLE 3
Physical Properties of the Three Top Mixtures

MIXTURES Sand	Soil	Amndmnt.	Gravel 2mm	Total Sand .05-2mm %	Silt .002-.05mm %	Clay .002mm %	Bulk Density g/cm-3	% PORE SPACE Capillary	Non. Cap.	Inf. Rate in. of H_2O/hr.	40 cm of H_2O Retention %
—— % by volume ——											
60A	20	20	0.0	94.7	3.1	2.2	1.36	20.2	28.8	7.8	14.8
60B	20	20	0.0	95.6	2.3	2.1	1.33	20.2	29.6	9.2	15.2
60C	20	20	0.0	95.0	3.1	1.9	1.45	17.3	28.0	7.1	11.9

Figure 2. Photograph of the profile of a greenhouse green composed of topmix B overlying a two-inch sand layer over 1 cm gravel.

the 100 percent sand plot and also below the 100 percent soil plot without a sand layer. The movement of silt and clay from the 100 percent sand into the gravel indicates that if this sand were used for the sand layer, it very likely would not prevent sand and silt movement into the gravel. Also, the case of 100 percent soil plot without a sand layer indicates that only very small amounts of silt and clay will move, even though large amounts may be present in the overlying topmix. An extensive root system network extending down to the gravel layer may have been instrumental in binding the soil together and preventing migration (Figure 1).

In the greenhouse study, golf green profiles were constructed in 12-inch diameter metal cylinders equipped with drainage ports at the bottom. Four inches of pea gravel or ⅜-inch gravel were placed in each cylinder (Table 2). Two inches of sand C (Table 2) were added to one-half of the cylinders of each gravel size to act as the specified sand layer. Top mixtures of three sands (fine, medium, and coarse) A, B and C with Lakeland soil and peat moss (Table 3) were designed according to the USGA specifications and placed above the sand layers. A cover of Tifdwarf bermudagrass was established and the equivalent of 100 inches of water was passed through the profile. Profiles using topmix A (60A-20-20, Table 4) showed no evidence of vertical silt and clay movement. The total silt and clay content in the overall topmix was 3.1 percent and only 3 percent immediately above the sand layer. When the sand layer was omitted the overall topmix silt and clay content was 3 percent and only 3.5 percent above the gravel layer. The presence or absence of the two-inch sand layer made no significant difference in the total pore space reduction in the gravel layer due to particle migration (Table 5). Profiles constructed using USGA mixtures of sands B and C with Lakeland soil and peat moss behaved similarly and did not exhibit any significant particle migration into either the sand or gravel layers (Figure 2).

THUS, BOTH THE data from eight-year-old field greens and simulated green profiles in the greenhouse which had been subjected to prolonged saturated flow, indicate a lack of downward silt and clay migration in golf greens built to USGA standards. In all cases, no significant effect of the two-inch sand layer was evident when proper size gravel was used. Thus, with properly sized gravel, a minimum amount of top mixture is washed into the gravel layer, and the presence of a coarse sand layer does not influence the amount of mobile materials. It is possible that most of the migrations take place during construction or shortly after, before grass roots have completely penetrated the top mixture. In all cases, the grass roots had penetrated down to the gravel layer by the time measurements were made, and they may have been instrumental in binding the topmix materials together and thus preventing particle migration.

Editor's Note — Please read carefully and note that only under certain circumstances can the sand layer be eliminated in putting greens built to USGA Green Section specifications. This is possible only when the particle size relation between the gravel and the top mixture (layer E in cross section profile on page 1) is correct. This means the use of pea gravel, where commercially available, or crushed stone in the ¼ to ⅜ inch range and a top mix that meets specifications described in the article "Refining The Green Section Specifications for Putting Green Construction," USGA GREEN SECTION RECORD, Vol. 11, No. 3, May, 1973. The recommendation for eliminating the two-inch sand layer *can only be determined* by physical soil analysis in laboratories equipped to test soils to USGA Green Section specifications for putting green construction.

TABLE 4

Gravel, Sand, Silt and Clay Contents of Topmix A from Greenhouse Greens

Topmix (Sand-Peat-Soil)	Gravel Size	Section	% Sand	% Silt	% Clay	% Total Silt & Clay
60A-20-20 with sand layer	Pea	Topmix	97.0a*	1.8a	1.3a	3.1a
		0-2" above sand	93.3a	2.3a	1.4a	3.7a
		Top sand layer	99.1a	0.5a	0.5a	1.0a
		Bottom sand layer	99.3a	0.4a	0.3a	0.7a
		Top gravel	8.8a	NA**	NA	0.8a
		Bottom gravel	4.0b	NA	NA	0.7a
60A-20-20 without sand layer	Pea	Topmix	97.0a	1.9a	1.1a	3.0a
		0-2" above gravel	96.4a	1.9a	1.6a	3.5a
		Top gravel	6.0a	NA	NA	0.9a
		Bottom gravel	5.0a	NA	NA	0.8a

*Values in a given column of a given section followed by the same letter do not differ significantly at the 5% level.

**Not analyzed.

TABLE 5

Percentage of Pore Space in Four-Inch Gravel Layer Filled with Sand, Silt and Clay after Passage of 100 Inches of Water Through Greenhouse Greens

Topmix Sand-Peat-Soil	Gravel	Presence or Absence of Sand Layer	% Pore Space Lost Due to: Sand	Silt	Total Sand, Silt & Clay
60A-20-20	Pea	With sand layer	10.7a*	1.2a	12.0a
		Without sand layer	9.0a	1.4a	10.4a
60A-20-20	⅜"	With sand layer	4.5a	1.3a	5.8a
		Without sand layer	15.0a	1.4a	16.4a

*Values in a given column of a given gravel size followed by the same letter do not differ significantly at the 5% level.

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I certify that the statements made by me are correct and complete.

Robert Sommers, Managing Editor

The Influence of the Sand Layer On Available Water Retention In a Golf Green

by DR. K. W. BROWN and J. C. THOMAS*

AN INCREASE IN pore diameter at some depth below the surface will disrupt the capillaries, which conduct the downward-moving drainage water, and thus will slow the drainage, even of wet materials, to nearly negligible rates. Thus, a layer of gravel under the top mixture used in the construction of athletic fields will result in the retention of water in the profile in excess of that which would be possible if free drainage were allowed to continue into a deep uniform profile.

The USGA greens specifications call for the inclusion of a two-inch layer of coarse sand between the top mixture and the gravel drain. This layer is to prevent the migration of soil particles into the drain field and to assist in the retention of water in the profile. The layer is difficult and expensive to install, and a reevaluation of its function was therefore undertaken. A previous report (Brown *et al.*, 1980) demonstrated that if appropriate size gravel is utilized, particle migration is minimal and the presence of a sand layer does not decrease the movement of particles. Over an eight-year period in the field, particle migration only decreased the available pore space in the gravel by 9.7 percent, and it is likely that most of this occurred during the construction. The present study was undertaken to evaluate the influence of the sand layer on water retention.

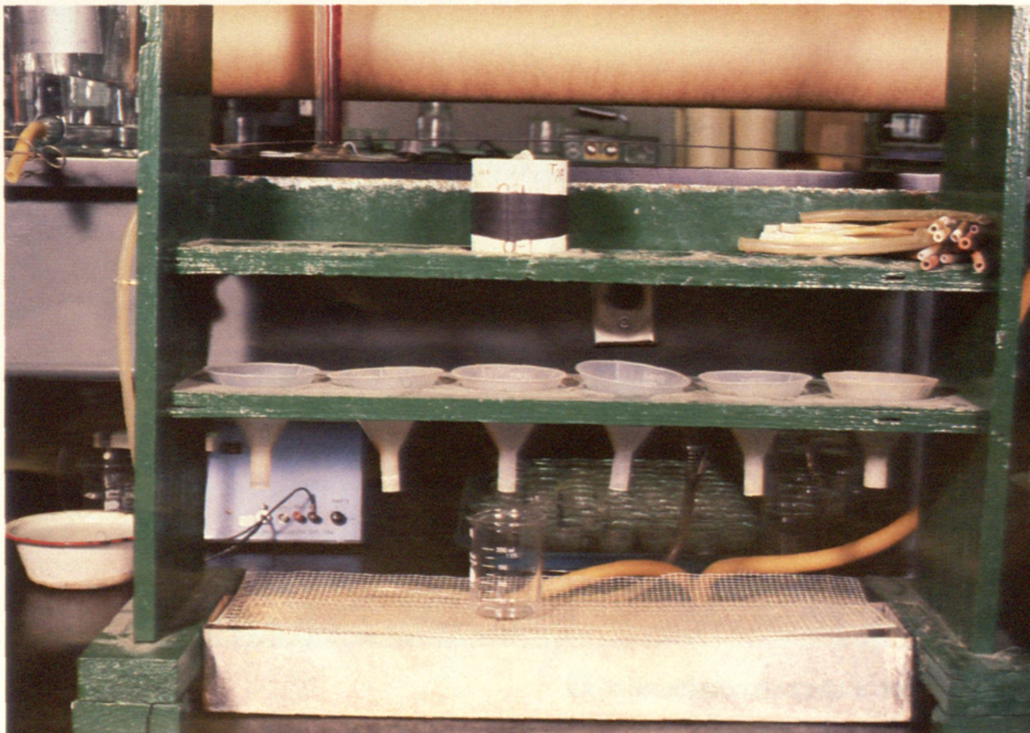
PROCEDURE

The amount of water retained in the top mixture above a layer of gravel can be calculated from water retention and unsaturated conductivity data of the gravel layer. This procedure, first suggested by Miller and Bunger (1963), utilizes the potential at which drainage in the gravel decreases to negligible amounts. For pea gravel, this occurs at a potential of 5 cm (Figure 1). The material immediately above the gravel layer is assumed to drain freely to this potential, and each layer above the first layer drains to a potential equal to -5 cm plus the elevation above the top of the gravel layer. Thus, retention data can be used to calculate the amount of water remaining in each layer when drainage becomes negligible. The water retention at the -15 bars wilting point can then be subtracted to give the plant available water. The bulk density is then used to convert the weight percentage of available water to the volumetric water content, which when multiplied by the depth of the layer gives the depth of water retained.

Water retention was measured on undisturbed cores 5.4 cm diameter x 2.9 cm thick, taken at the end of the experiment from containers of brick sand (BS), concrete sand (CS), 5 percent Houston Black clay (HB5) and 20 percent Houston Black clay (HB20). At potentials greater than -50 cm of water, a tension table was used while at lower potentials, the ceramic pressure plate extraction technique was used.

The slopes of the water retention curves shown in Figure 2 are sufficiently similar to indicate that the pore size distribution between even the finest mixture and the coarse sand do not differ greatly. Furthermore, the differ-

Constant head infiltration rack used to measure infiltration rate of compacted cores.



*Associate Professor and Research Associate, respectively, Soil and Crop Sciences Department, Texas A&M University.

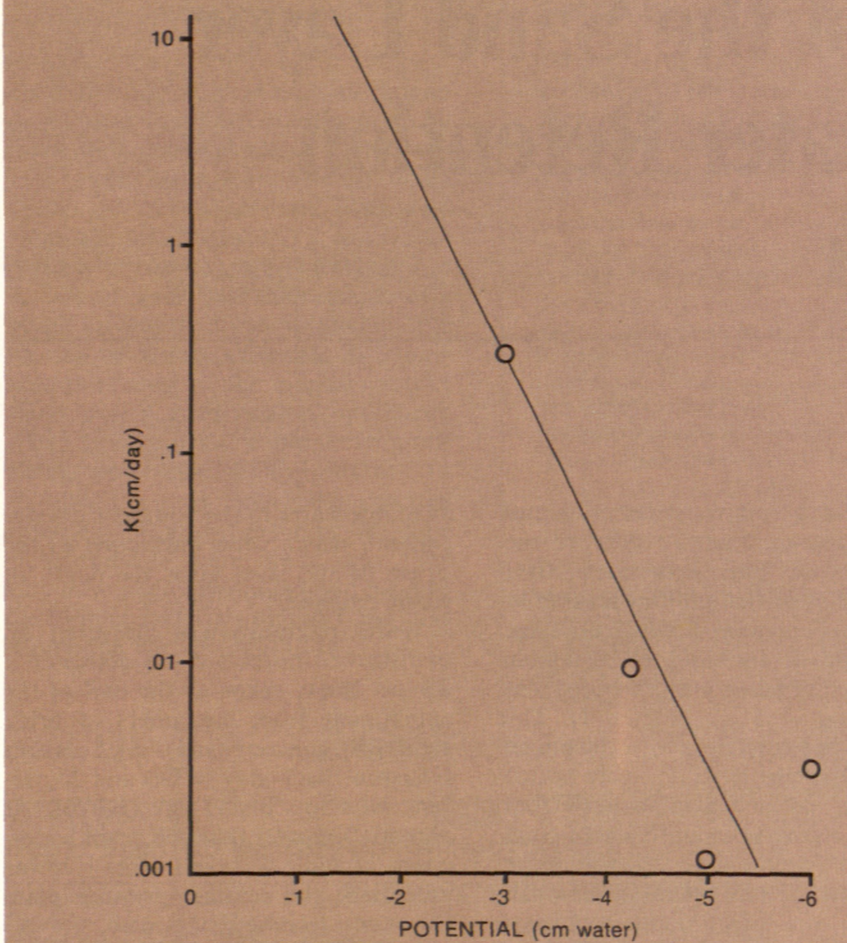


Figure 1. The unsaturated conductivity of pea gravel.

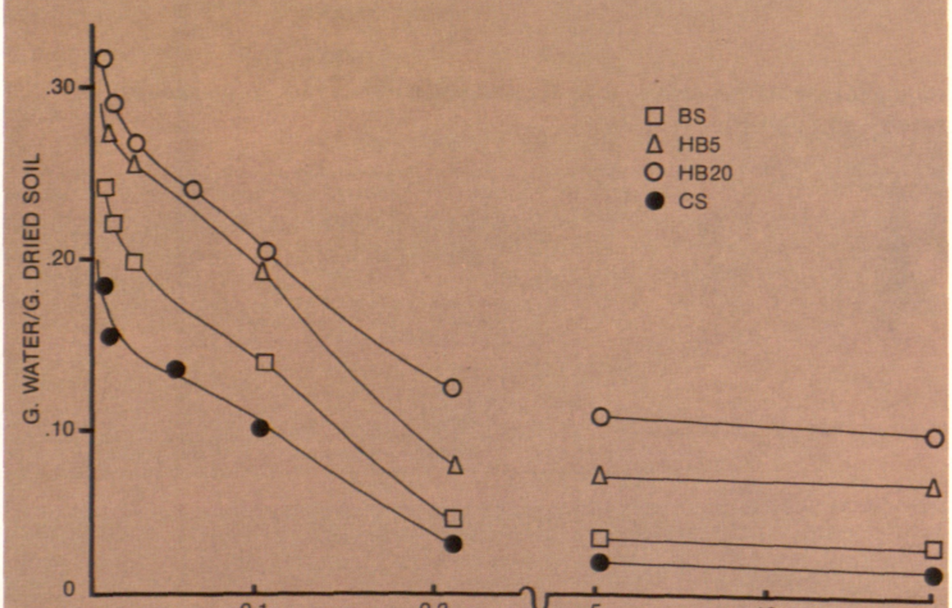


Figure 2. Water retention as a function of water potential.

ences in pore size distribution between either of the mixtures or of the sands and the gravel are very large and are the predominant factor controlling the water retention. Therefore, the calculation can be done utilizing on the gravel interface as a water flow control, whether or not there is a sand layer above.

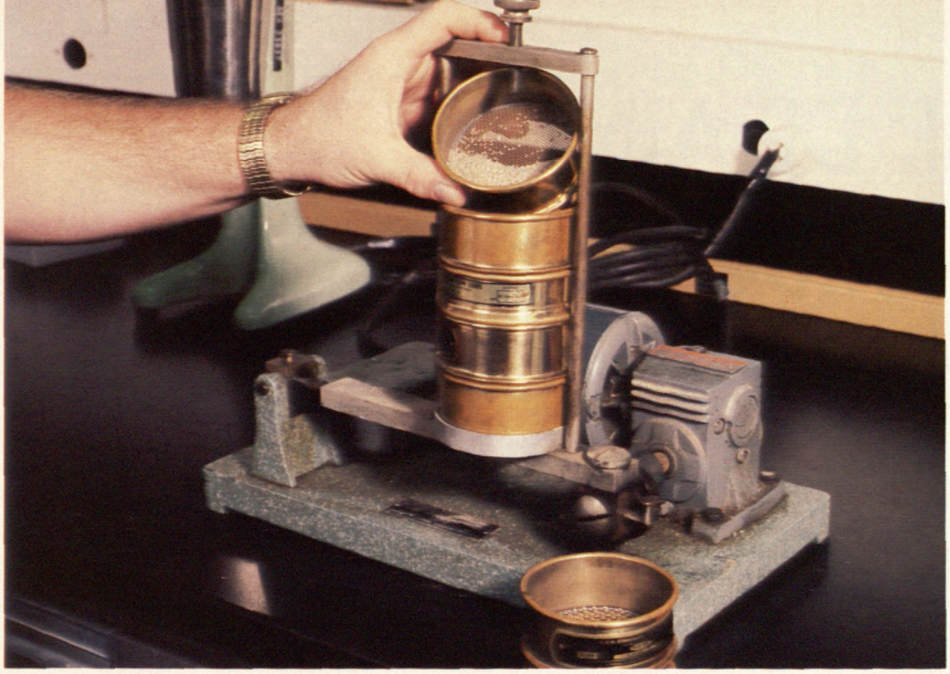
This was done for two different materials (BS and CS) and two mixtures (HB5 and HB20) for which water retention and bulk density data were available. The profile densities are shown in Figure 3. Of the four materials, the coarse sand represents a material which could be used for a sand layer. The other three materials could be considered as top mixes, but the brick sand has too high an infiltration and too low a water retention to meet the USGA standards for a top mixture, while the HB20 has too low an infiltration to be suitable. Thus, only the HB5 mix meets the USGA specifications. The calculations were done, however, on all three materials to provide a range of data, with and without a sand layer. Calculations were performed assuming a 30-cm thick layer of compacted topmix above a pea gravel, without a sand layer, and a 25-cm thick top mixture underlain by a 5-cm thick sand layer on top of the gravel layer. The results given in Table 1 indicate only minimum differences between the retention with and without sand layers, and in all cases the water retention with the sand layer is slightly less.

Thus, the data from the report of Brown *et al.*, 1980, and this report suggest that the sand layer can be omitted without damaging the gravel under drainage and without reducing the amount of water available to the turf.

LITERATURE CITED

Brown, K. W., J. C. Thomas and A. Almodares. 1980. To investigate the necessity of a sand layer between the top mixture and gravel layer in golf green construction. Final Report to the USGA Green Section. See previous article, this issue.

Miller, D. E., and W. C. Bunger. 1963. Moisture retention by soil with coarse layers in the profile. SSSAP 27:586-589.



Sieves and shaker used to analyze sand fraction of putting green topmix.

TABLE 1
Calculated Amounts of Available Water in 30 cm Profiles Of Three Top Mixtures with and without Sand Layers

Mixture	Sand Layer	cm of Available Water in a 30 cm Profile
BS	with	7.30
	without	7.52
HB5	with	6.62
	without	6.69
HB20	with	7.23
	without	7.46

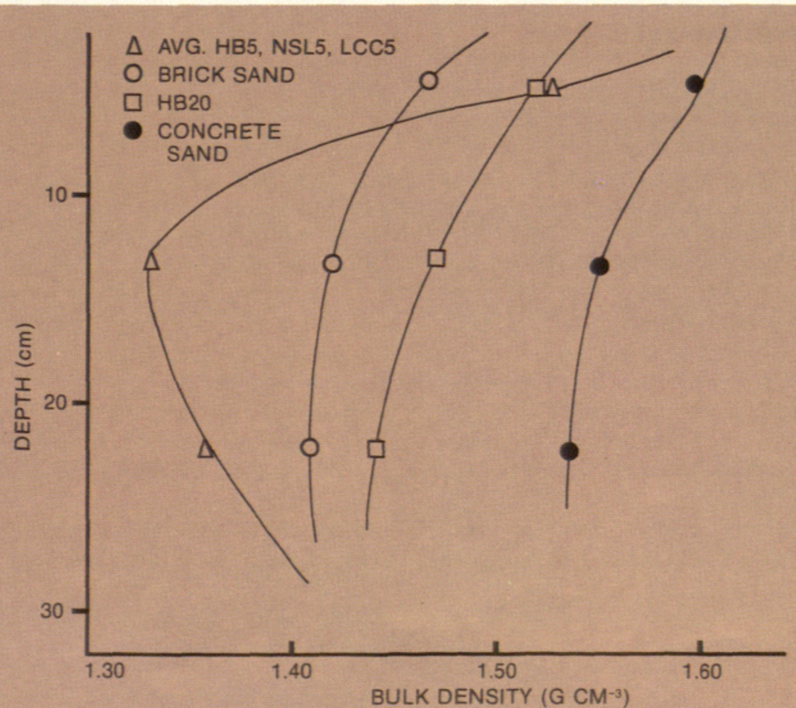


Figure 3. Soil bulk density as a function of depth.

Green Section Educational Conference

The annual USGA Green Section Educational Conference will be held at the Anaheim Convention Center, Anaheim, California, on Thursday, January 29, 1981. Because of a conflict in conference dates, the Golf Course Superintendents Association of America has graciously invited the USGA to use the entire day Thursday to present the Green Section's Educational Program. The USGA salutes this fine gesture of cooperation. We look forward to being at Anaheim and hope that we can significantly contribute to the success of the GCSAA's 52nd International Turfgrass Conference and Show.

Golf Course Superintendents Association of America

James E. McLoughlin recently began his new duties as Executive Director of the Golf Course Superintendents Association of America, in Lawrence, Kansas. Since 1966, McLoughlin had been Executive Director of the Metropolitan Golf Association, composed of clubs in the area around New York City, in New York, New Jersey, and Connecticut. He is also a member of the USGA's Handicap Procedures Committee.

The GCSAA was founded in 1926. It is composed of 4,700 members in the United States, Canada, Mexico, and 17 other countries.

OPEN STONE DRAINS: They May Not Be Pretty But They Work

by STANLEY J. ZONTEK
Director, North Central Region, USGA Green Section

THE MAY, 1968, issue of the GREEN SECTION RECORD carried an article entitled, "Better Drainage Through Slit Trenches," by James L. Holmes, former Midwestern Agronomist with the USGA Green Section. In this article, Mr. Holmes discussed various new methods of installing "slit trenches" on golf courses. Basically, these drains were narrow trenches dug in wet areas and filled to surface level with gravel or crushed stone. At that time, placing stone to surface level in an open trench was novel on golf courses, though the idea was borrowed from farming. From this beginning, the idea spread and became a popular method of quickly draining trouble areas on golf courses.

Today, for all practical purposes, slit trenches have become the predominant type of golf course drain where the goal of the drainage project is to remove excess surface water quickly from low wet spots or by intercepting surface water before it can accumulate and cause problems with maintenance and playability.

In this article, we will discuss the necessity of good drainage and bring up to date the original idea of the slit trench and show that in turfgrass management, some ideas get better with age.

Why Good Drainage in the First Place?

It is fair to say that good drainage is one of the basic prerequisites for good golf turf. Without it, you will have trouble growing fine turfgrass no matter how good a turf manager you may be. Many reasons support this statement. Briefly, they include: (A) Areas of poor drainage encourage increased winter injury as a result of ice accumulation and crown hydration through freeze/thaw cycles. (B) Areas of poor drainage cause increased summer damage. During the summer stress period, these same areas are the first to experience scald, wet wilt and disease. (C) Wet spots usually cause areas of thin turf. Because the best weed control is a healthy turf, weeds quickly dominate such areas. Crabgrass, knotweed and *Poa annua* all encroach and make these wet areas aesthetic, maintenance and playability problems. Good permanent turfgrass can only be supported on soils that have good drainage. Poor drainage areas are difficult to maintain. Even mowing the grass becomes a chore in wet areas. Hand cutting with light equipment is usually necessary on wet areas, and this is inefficient use of manpower and equipment. With today's tight budgets, recurring expenses such as this cannot be tolerated for long.

Wet areas are also bad for play. They cause embedded or lost golf balls, soft, uneven footing, tall lush grass, and seemingly perpetual need for relief from casual water. These wet areas are always aggravated by irrigation, especially long, soaking waterings. Is it any wonder, then, that drainage projects are continually underway to correct these deficiencies on many golf courses? Some of this work is effective, but, regretfully, some of it is not. The choice of the proper drain is often the real problem. Be careful to select the correct type of drain for the specific problem.

What Type of Drainage System Is Best?

As agronomists for the Turf Advisory Service of the USGA Green Section, we regularly see all types of drainage work, ranging from small post-hole dry wells to massive drainage projects involving the professional engineering of ponds, dikes, ditches and streams. The choice of drain involves analyzing the magnitude of the problem and determining what type of drain will do the job effectively. Where surface water is a problem, the slit trenches will usually work best for you.

This article will only discuss this one type of golf course drain . . . the slit trench with drainpipe included. For further reading, the following articles have appeared in this publication and feature other types of golf course drains. These are:

"Better Drainage Through Slit Trenches," May, 1968 — J. L. Holmes.

"Sump Pumps for Unusual Drainage Problems," January, 1977 — Dr. R. E. Engel.

"Little Things Count in Tiling Golf Courses," January, 1968 — S. Moore.

"Drainage: Why and How," May, 1975 — C. H. Schwartzkopf.

"Drainage: So Easy It's Difficult," January, 1976 — W. H. Bengeyfield.

Originally conceived, stone drains were just that, columns of crushed stone or pea gravel placed in a ditch and filled to the surface. No pipe was included. These were the classic "French drains." With the advent of continuous perforated plastic pipe, another dimension was added, evolving into what we have today, that is, a relatively quick, easy to install, and an extraordinarily effective golf course drain called, for want of any better name, a gravel or crushed stone slit trench.

How Are They Installed?

Generally, these drains are installed using a trenching machine as in Figure 1. The machine makes a neat, clean

vertical cut, generally from several inches to several feet deep. The width of the trench ranges from three to eight inches, with six inches a typical width.

The machines are easily maneuverable so that the drainage trench can literally be snaked through low spots, connecting a series of these wet areas into one neat drainage network. This is a departure from the textbook "gridiron" or "herringbone" drain patterns that were common on many golf courses. This type of network is perfect for each drainage problem area found on the golf course. After all, not all drainage problems call for a gridiron or herringbone pattern.

Once the trench has been dug, it is important to check the grade to see that water will flow downhill. If high or low spots exist, they should be brought to grade so that a smooth, gradual slope is achieved at the bottom of the trench.

In some instances, a gradual pitch can be created on flat areas by setting the trench shallow at one end and deepening it as the trencher moves along, effectively achieving adequate pitch even in areas where slope is a problem.

At least one inch of crushed stone or pea gravel is then laid in the bottom of the trench as a bed for the pipe. Pipe sizes vary from two to eight inches wide, with four-inch plastic pipe usually the most frequently used. Once the layer of stone is down, the pipe can be placed on top with the remaining stone filled to the soil surface and left uncovered (Figure 2). The drainpipe and the open stone surface are the key elements in making this type of drain long-lasting and effective!

Crushed stone and gravel comes in assorted sizes, but for drainage purposes should range from ¼ inch to a maximum of about ¾ inch. Larger stone, although effective, tends to interfere with the mowers, and sometimes damages them. Therefore, depending on stone availa-

Figure 1. While the procedure is the same for every drain line, the difference in an open stone trench is that the soil is hauled away and the pipe is completely covered with gravel or crushed stone. Ridgewood Country Club, New Jersey.

Figure 2. Pattern showing versatility of a slit trench system — two lines in gridiron fashion empty into a line that carries the excess water down natural incline. Note crushed stone in trench is filled to turf level. Wildwood Country Club, New Jersey.

bility, price, and where the stone drain is located, a range of sizes from a minimum of ¼ inch to a maximum of ¾ inch is preferred.

Keep the Stone Surface Open

If there is a key to the effectiveness of this type of drainage system, it is keeping the stone open to the surface (i.e., uncovered by sod or soil). Leaving it open permits the rapid removal of excess surface water, whether from rainfall or irrigation. It is essential to remove excess water rapidly. The water moves over the surface, reaches the voids of the open stone, moves down through the stone and pipe below (in stone the water moves laterally and vertically) while being carried away . . . rapidly. Surface water is not allowed to accumulate. Therefore, grass is not subject to the stresses of submergence in summer or winter, and as a result the soil is much firmer for maintenance and play.

If there is a drawback to this type of drain, it is the very thing that makes it so very effective — the gravel or stone at the surface. Initially, it is unsightly, but under the Rules of Golf or a Local Rule, relief is given if a player's stance or swing is affected. Further, given time, the grass will grow over the stone to cover these drains, yet they will still function effectively for years thereafter (Figure 3).

Sometimes, after a few years, the turf over the stone may become sod bound. This condition can be corrected by periodically removing some of the sod over the stone and, if necessary, adding more stone to bring the stone to the level of the turf. This is not a major project and should be done only on an as-needed basis.

In Summary

Rapid removal of excess water is the strength of the open stone drain. Other types of drainage systems can and will work effectively on a golf course. Indeed, perhaps the most effective drainage program on a golf course is one that makes use of all the types of drainage systems. The open stone drain with pipe included seems to effectively fill the need for rapid removal of excess surface water from in-play turf areas. After all, when surface water accumulation is not a problem, the turf is firmer after rain and will support golf carts, maintenance equipment and foot traffic better. The grass is also healthier. Keeping the course open, maintainable and playable for a longer time is certainly the goal for any progressive turf manager. The open stone drain is one tool that helps achieve this goal.

Author's Note: In our experience, some golf course superintendents and their memberships have been pleased with this type of drainage system and others were not. The choice is always up to the club and the turf manager who maintains the facility. Most often the criticism is due to aesthetics, not function. They are effective golf course drains. Therefore, if aesthetic considerations are secondary to good drainage, give these slit trenches a try. There is little to lose and much to gain in member satisfaction and added days of pleasurable playing time.

Figure 3. Turf eventually grows over the stone, but this does not impair the effectiveness of the drainage system. Twin Hills Country Club, Massachusetts.

The Triplex "Ring"

by **JAMES T. SNOW**, Agronomist

THE ADVENT OF THE triplex putting green mower in the late 1960s brought with it great expectations for reducing labor costs while at the same time improving the quality of putting green turf. For many of the golf courses that use triplex mowers, this dream has been at least partly realized: the number of hours needed to mow the greens has been greatly reduced and turf quality has not suffered significantly. For others, however, the triplex mower has been a mixed blessing. Though time spent mowing greens has been reduced, extra effort has been needed to cope with new problems associated with the use of the triplex. For example, the wear and compaction caused by turning the

As the season progresses, the triplex "ring" becomes evident at the outer perimeter of the putting green.

triplex mower off the green after each pass may demand that the collars be aerated and topdressed more frequently and hand-watered regularly. Collars are often scalped when units are lowered too quickly or raised belatedly at either end of the pass. There are also the mechanical malfunctions, when individual units on the triplex refuse to rise upon command and when hydraulic lines leak or burst, creating unsightly turf damage which may last for weeks or months.

Perhaps the most common problem associated with the use of the triplex mower is a condition which could be entitled, for lack of a better term, the "triplex ring." It is best described as the ring of weak, scalped or dead grass around the perimeter of the green, in the area where the triplex mower makes its final cleanup pass. The reasons for this problem are easy enough to appreciate. This perimeter ring is the only area to receive double traffic each day the greens are mowed, once when the mower is making its straight passes across the green and again when it makes the cleanup cut. It is also the only part of the green where the mower travels the same path every day, thereby compounding the wear and traffic problems imposed upon it as compared to the other turf areas on the green.

Finally, the cleanup pass is the only time that the mower is actually turning on the green itself, a situation similar to turning mowers at the ends of fairways and tees. In each case, the mower creates downward and lateral pressures during the turn which combine to produce greater wear and soil compaction than if the machine were traveling in a straight line. The sudden turning of a golf cart on wet fairway turf is a more dramatic illustration of this principle.

There seems to be no single solution to the triplex ring situation in many instances, but there are a number of practices which when combined can help to alleviate the problem.

Tire abrasion weakens permanent turf and Poa annua *quickly takes advantage.*

Mowing Practices

Sometimes the triplex ring syndrome can be completely resolved by modifying mowing procedures. To begin with, insist that the mower go more slowly as he makes the final pass around the green with the triplex. A fast-running vehicle will do much more damage during a turn than a machine that is moving slowly.

Because the symptoms of triplex ring will tend to be more pronounced during stress periods, especially during the summer, any practice or schedule which relieves the severity of the wear or decreases the number of times the perimeter area is cut during that time will help reduce turf damage. If the grass is not growing too fast, skip the cleanup pass every other day or bring the final cut in from the edge by six to 12 inches every other day so that the tires do not always travel in the exact same path. Consider using hand mowers on the greens which exhibit triplex ring symptoms, especially during stress periods. There is no doubt the triplex mowers produce more wear and compaction on the perimeter of the green than do the single-unit mowers. It's a rare case when all 18 greens on a given golf course display triplex ring symptoms, however, so the time needed to mow a few of the worst greens with hand mowers is usually not prohibitive. A good alternative would be to use the triplex to mow the green but use the walk-behind mowers to make the cleanup passes, a practice which many clubs use successfully for all 18 greens throughout the season. Other alternatives would involve mowing every other day with hand mowers or using triplex mowers only on weekends. Some golf courses use the triplexes only during the spring and fall, when the labor supply is likely to be at its lowest point.

Finally, raising the cutting height slightly during stress periods can help, but this should be something of a last resort. If a program of light, frequent verticutting is used to groom the greens, be sure that a perimeter pass is *not* made with the verticutting units.

Cultivation and Cultural Management

Getting back to the basics of turfgrass management, the development of a strong, healthy grass is the best way to resist triplex ring damage. Avoid overwatering and overfertilizing at all costs. Too much water and nitrogen can create a weak, lush turf which is more susceptible to wear injury. Wet soils also compact much more readily, inhibiting root development and resulting in a weakened turf.

To overcome the effects of compaction and wear in the perimeter ring, aerate the soil more frequently. If the greens are already aerified once or twice during the season, then aerate the perimeter ring area by itself several other times. Aerating (coring) achieves positive results even when done in the middle of a stress period, so don't hesitate to aerify if triplex ring symptoms begin to appear. If chronic soil compaction problems are related to the texture of the soil in the greens as well as to the use of the triplex mower, then begin modifying the soil in the greens by topdressing with a compaction-resistant material, one containing a high percentage of sand. Have the topdressing material tested by a soils laboratory in order to insure proper infiltration rate, pore space and bulk density.

Design and Environmental Factors

Most of the time the symptoms of triplex ring will not appear uniformly around the perimeters of all the greens. Weakness or injury is most likely to develop in areas of the perimeter ring where other stress factors also come into play. Sharply contoured greens often develop this malady, especially where the mower makes its sharpest turns during the cleanup pass. Sometimes this problem can be resolved by recontouring the green so that sharp turns are eliminated.

Triplex ring symptoms often manifest themselves on greens only in entrance and walk-off zones, especially when traffic is restricted to narrow passageways by steep banks, sand bunkers or other obstacles. If the area around the green can be redesigned to provide several different entrance and exit channels, very often the triplex ring will disappear.

The presence of trees near a green may create enough extra turf stress to produce visual symptoms in the area of the perimeter cut. Too much shade, poor air circulation and tree root competition all weaken the resistance of the turf to the additional wear of the triplex mower. Removing or thinning some of the nearby trees in order to improve sunlight penetration and air circulation will usually help alleviate the problem. The trees should be root-pruned by digging a trench between the trees and green, placing tarpaper or some other heavy-duty material in the trench and backfilling.

There are many types of stresses which may have a detrimental effect on the health and vigor of putting green turf. By carefully investigating the causes of this stress, adjusting mowing and cultural programs accordingly, and creating a favorable environment for plant growth, some of the problems associated with the use of the triplex putting green mower can be eliminated.

More frequent aeration is required on collars and the outside perimeter of the green.

Golf Course Observations From South America

by JAMES B. MONCRIEF
Director, Southeastern Region, USGA Green Section

AT THE INVITATION of the *Asociacion Argentenia de Golf*, it was my privilege to inspect courses in several countries in South America. Mr. Ivar Brodstrom and Dr. Jorge Ledesma were primarily responsible for making this trip possible. They arranged an itinerary that included courses in Argentina, Brazil, Chile and Uruguay.

Courses in South America were designed shortly after the turn of the century. As in North America, the European impact on golf and design was evident; the English and Scottish influence was especially strong. Now, however, new courses are being designed by local talent, but they still reflect the strategy and design of the courses already there. Some of the new courses compare favorably with any in the United States.

The first leg of the journey led to Uruguay and three clubs, the Club de Golf del Uruguay, Club de Lago, and the Punta del Este Club. Those in charge of these clubs were eager to learn of new developments in grasses, machinery and management techniques. They were interested to learn about grasses that are used in the Atlanta, Georgia, area because their latitude is 34° south of the equator, whereas Atlanta is 34° north of the equator and climate and growing conditions are somewhat similar in Montevideo. One of the clubs was in the process of converting bermudagrass greens to Penncross; one, a new course under construction among the sand dunes, had planted Tifgreen (328); the third was an old established course with native bermudagrass greens.

The Club de Golf del Uruguay was very much interested in the USGA

Temporary clubhouse . . . a renovated silo, Las Praderas Club, Argentina.

Flood irrigation is practiced in South American countries . . . note diversion boards.

Green Section's method of building greens. The man in charge was very well informed about the use of a high percentage of sand of a proper particle size range in soil mixes. The drainage system under greens will be improved as greens are reconstructed. One question that they were all very much concerned about was how to keep bermudagrass out of bentgrass greens. They were pleased to know that it is successfully done in the United States. This club had one of the few bentgrass nurseries observed, and it was being increased. At 2 P.M. on Sunday afternoon, play stopped and the golf course became a park, open to the public. No golf was allowed; neither was access to the clubhouse permitted. Only the golf course was used to walk, picnic, play games and admire.

Many plants in Uruguay are of the same genus that we have throughout the South; however, their species were different. Pampasgrass, a weed common in Uruguay, is considered an exotic ornamental plant in the United States. Another grassy weed common on all courses in Uruguay is *Paspalum vaginatum*. Chemicals are available for the control of weeds and insects. Most of their chemicals are imported from Japan or Britain. Presently, their laws are not as stringent as ours. Two common insects observed there and in this country are mole crickets and sod webworms.

In Uruguay, most use the walk-behind green mowers, pull-type fairway units and a quick-coupling irrigation system. The irrigation equipment is inadequate, but this will probably be resolved soon; irrigation companies are beginning to come to South America.

ARGENTINA

There is a tremendous variation in climate in Argentina from the north tropical area to the tundra in the south. Our trip covered the north-central area from the Atlantic Ocean to the Andes Mountains. Bentgrasses were used on the greens from Buenos Aires south, while bermudagrasses were used to the north. The first Tifgreen was introduced into Argentina in 1967, and it is being used on greens, tees, and fairways. Argentines call it Tifton grass. Tifdwarf is used on a limited scale, while common bermudagrass is used most of all in fairways and roughs. The first greens built to USGA Green Section specifications were started after 1972. The soil and sand from the Olivos Club near Buenos Aires was sent by special permission from the United States Department of Agriculture to the Mississippi State Soil Laboratory, which at that time was being supported by the USGA. These greens built to USGA specifications have been just as successful as USGA greens built in the United States. Other clubs are beginning to build greens using a high sand topmix. We saw this at Las Praderas Club, a new club near Buenos Aires. Presently, soil labs provide chemical analyses only; however, young college

(Above) Bunker shorings, thick wooden posts, were first used in this manner over 50 years ago.

(Left) Paspalum vaginatum *— a prevalent weed throughout fine turf areas.*

Mixing topsoil without modern equipment requires the entire work force.

The first hydraulic fairway unit recently purchased by the Olivas Club, Argentina.

graduates are showing interest in physical soil analyses similar to that performed when preparing a topmix to the USGA Green Section specifications for putting green construction.

Angel Reartes, superintendent at Las Praderas Club, spent several weeks observing golf courses in the United States and attending meetings pertaining to golf course operations. This is the only club under construction that we visited in Argentina. It will be equal to any of the latest golf courses being built in the United States! It is situated on an old estancia (ranch), and so far 46,000 flowering shrubs and trees have been planted. The temporary clubhouse is a large silo with several floors connected by a spiraling outside stairway.

Penncross was the only bentgrass being used on greens. In Buenos Aires and south, bentgrass was used on most of the greens. Most greens were built with a high silt-clay soil. They had only surface drainage, and yet playing surfaces, surprisingly, were very satisfactory.

One common disease, dollar spot, was evident on many greens, and fungicides were being used to control it. We also saw leaf spot and fairy ring.

The soil, especially in the pampas area, provides an excellent growth medium for most low-fertility plants. The terrain is flat with heavy clay soil.

There were some weed problems common to the golf courses and many were familiar to me, such as sedge, pennywort, dichondra, goosegrass (which they call chicken grass), *Poa annua*, crabgrass and a number of *Paspalum* species. A weed that was common to all the courses in all the countries we visited was *Paspalum vaginatum*. Goosegrass was not as abundant or as widely spread there as it is in this country.

Dallisgrass, which Argentines call honeygrass, was widely scattered. It is a problem on most golf courses. On some courses it was not being controlled adequately, while on others post-emergent chemicals provided excellent control.

One weed, a juncus locally known as hog's hair, was well adapted to green maintenance practices. Some greens were totally rebuilt in order to control this weed, but other clubs thought this was too drastic a weed control measure. These clubs were using various chemicals, trying to find one that will selectively kill it. It is very important that they find a control, because it is a very stiff-bladed plant which very definitely has an effect on the roll of the ball.

Various insects were encountered. One, a small cricket, was called grillo (meaning strong, tough). They burrow and bring up piles of soil, similar to earthworm casts but larger and more abundant, following rains. The heavy clay soil adheres to the rollers on the mowers and gets into the reels. The cost of insecticide for complete control of this cricket is too much in a highly inflated economy. Therefore, greens and tees are protected with insecticides while the fairways and roughs are not.

The change in embarcation laws now allows equipment to be imported, and we saw the latest equipment available beginning to be used. The first triplex greens mower was purchased by Osvaldo Merengo for the Rio Cuarto Golf Club. The first fairway unit with hydraulic driven reels was being used at the Olivos Club. Companies from the United States now have representatives who provide sales and service for golf course equipment in Argentina.

Two clubs in semi-desert on the eastern edge of the Andes had a very different climate from the other clubs visited in Argentina. These would be more comparable to conditions found at clubs in west Texas or New Mexico. Water is a concern, and flood irrigation is practiced on fairways. Sprinklers are used on tees and greens. Their source of water is the melting snow from the Andes, brought in by rivers and canals.

CHILE

Francisco Humphreys, president of *Federation Chilena de Golf*, was responsible for our visit to clubs in Chile. Their main concern was how to keep the bermudagrass out of bentgrass greens.

We visited four clubs in Santiago and one on the coast. Climatic conditions in Chile were cool and dry. Flood irrigation is practiced, except on tees and greens where quick-couplers are used.

Nine new holes were built at the Polo Club and a modern irrigation system was installed. Some of the old fairways are still being irrigated by flooding. The source of water is melted snow from the Andes Mountains.

The caddie scene . . . shades of yesteryear — U.S.A.

Grillo, a cricket that creates soil casts over the turf . . . somewhat similar to earthworm casts except they are larger and more abundant.

One weed we saw other than *Paspalum vaginatum* was *Pennisetum clandestinum* (kikuyugrass), which is one of our more difficult weeds in North America, also. The most common disease observed in Chile was dollar spot.

Numerous plants grow together that we see growing under different climatic conditions in the United States. Flowering shrubs and trees are abundant where water is available. Annual flowers abound, are colorful and beautiful.

BRAZIL

Golf courses in Brazil were similar in design to those in other South American countries. Golf is played by a very elite group. *Paspalum vaginatum* was observed throughout all of the golf courses, especially on greens. Aquatic plants are commonplace, since the water supply is lake water. Water is available but not abundant for golf courses. The closer we came to the tropics, the more different types of weeds we encountered. Goosegrass was most prevalent. The men in charge of golf courses were eager to exchange information on controls for this and other weeds.

There is no problem hiring employees; labor is plentiful. Caddies are used at most clubs and there are few golf carts. They are privately owned.

Gavea Golf Club, in Rio de Janeiro, was the last club visited before returning to the United States. The vegetation was tropical, lush, and exotic. We saw many plants that are treasured as house plants in the United States growing wild in the outer areas of the golf course. It was surprising to note that drought conditions exist even in the tropics and irrigation patterns were very obvious.

The art and science of golf course management in South America is far behind ours in North America. However, the enthusiasm and desire to excel is evident. In time they too will excel.

Correction: In the article "Water Quality and Drainage" by J. A. McPhilomy, July-August 1980 GREEN SECTION RECORD, we incorrectly listed sand particle sizes as ranging from 25 to 50mm and it should have read 0.25 to 0.50mm.

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TURF TWISTERS

BE CAREFUL — USING HERBICIDES

Question: Are there any pre-emerge herbicides that you can use on putting green turf and overseed at the same time or within a reasonable time after the herbicide is applied? (Maryland)

Answer: The only pre-emerge that can be used in conjunction with overseeding is Siduron (Tupersan), but this herbicide can only be used on certain bentgrasses; therefore, it is not recommended for bentgrass putting greens. However, be advised that Siduron is especially lethal to bentgrasses that turn purple in fall. This is the "Washington type" bentgrass, so-called after the original Green Section Washington selection, which is one that takes on a purple hue in fall.

SODDING ZOYSIA COLLARS

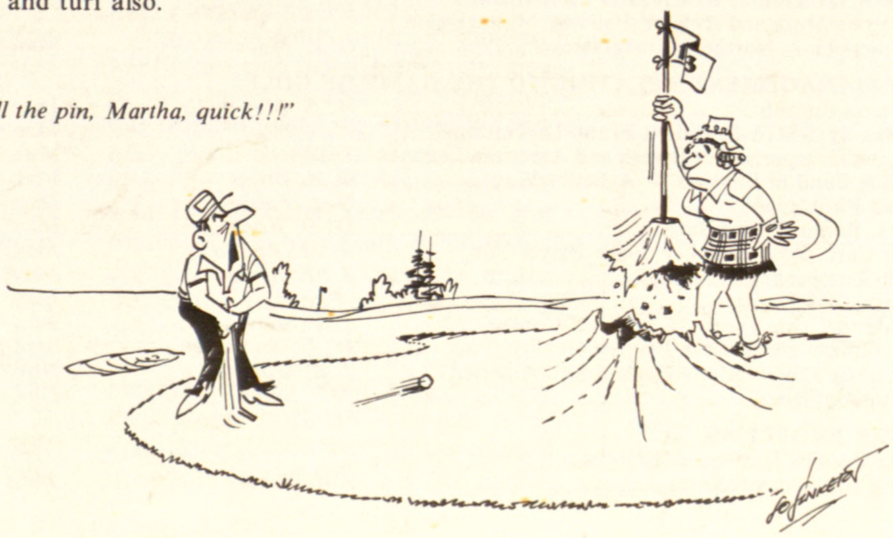
Question: We would like to use zoysia to keep bermudagrass out of our bentgrass greens. Will it serve well in this particular role? (Kansas - Oklahoma - Texas)

Answer: We have been asked this question many times and the answer is no. Zoysia has been tried by others for this purpose in your states, and in all cases we have seen it fail. It will work for two or more years, depending on the width of the zoysia band that is put down initially, but under the high-fertility program common to collars and the reasonably high amount of moisture required, the bentgrass overcomes the zoysia from the green side and the bermuda overcomes the zoysia from the bank or approach side. However, in areas of low fertility and reduced irrigation, such as around sand bunkers, zoysia works reasonably well in holding the bermudagrasses in check.

AND CHANGING HOLES

Question: We often receive complaints that the turf is sometimes raised, causing the ball to stop at the edge of the hole on putting greens. What causes this and how can we correct this situation? (Maine)

Answer: There are several possibilities: (1) The worker changing the cup may be tilting the hole-cutting tool as he removes the plug. (2) The worker may be raising the soil when he removes the cup setter — the device that assures the liner will be set one inch below the turf surface. If not removed vertically, the cup setter device could raise the turf. (3) If the flagstick sticks when players attempt to remove it, the cup liner will raise the soil and turf also.



"Pull the pin, Martha, quick!!!"