Better Turf for Better Golf

TIMELY TURF TOPICS

from the USGA Green Section

SOIL AND TURF RELATIONSHIPS

A Report on Some Studies of the Physical Properties of Putting-Green Soils as Related to Turf Maintenance

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The purpose of a putting green is to provide for the players a firm, smooth surface which is true and accurate so that a properly stroked putt will roll toward the cup in a satisfactory manner. The quality of the putting surface, composed of the closely cut, densely knitted sod of grass plants, is affected by many factors which can be dissociated for individual study and evaluation only with extreme difficulty. Because of the highly specialized nature of the turf and the limited areas involved, it is understandable that the scientific studies of many of the factors have lagged far behind the practical aspects of the work.

A great deal of study has been devoted to the successful search for strains of bentgrasses which would develop superior putting surfaces. Work with improved strains of Bermudagrass is in progress. Similarly, problems of diseases, insects and weeds, for the most part, have been solved satisfactorily from a practical standpoint. Soil-turf relationships from the chemical standpoint have been studied closely, and the result has been an improvement in fertilizer practices, with a corresponding improvement in turf quality. Studies of the physical properties of putting-green soils have received scant attention in proportion to their importance in relation to plant growth.

It has been suspected that many of the difficulties encountered in providing continuously satisfactory putting surfaces are traceable to the physical nature of the soil underlying the turf putting surface. This assumption can be made logically on the basis that, under the skilled supervision of a competent golf-course superintendent, each putting green receives the very best care in order to provide the playing qualities that are demanded.

In spite of the best of care and attention, it is significant that, on nearly every golf course, there is a "best" green and a "worst" green. By "best" is meant "easy to maintain," and by "worst" is meant "difficult to maintain."

The "worst" green invariably requires more frequent treatment for diseases or insects or both. The turf, usually composed of the same grass that is on the "best" green, often becomes thin and is more readily infested with weeds. The thin turf provides little resistance to the ball and putts are likely to skid. The green then is called fast or slippery. Watering must be done with greater care to avoid sogginess which may encourage algae. During periods

NOTE—Appreciation is expressed to Clyde W. Decker for the mechanical analyses in this article.

of intense heat and high relative humidity, it is the "worst" green that must be watched closely and managed with extreme care to avoid damage to the turf.

Because the "worst" green actually gets more and better care in the matter of surface treatments than the "best" green, it is entirely logical to seek the answer in the physical make-up of the soil in an effort to discover some of the reasons for the differences in response to treatments. This is particularly logical because in most cases the penetration of the root systems is noticeably greater in the "best" greens.

The value of the related functions of good drainage and aeration in producing satisfactory growth of grass plants cannot be questioned, particularly as it pertains to grass plants which receive heavy traffic and which are cut every day at 3/16 inch to 4/16 inch. It must be recognized that this is highly specialized management and that, to maintain grass growth under these conditions, the soil should be of the best in every respect.

Few putting-green soils are natural soils. They are synthetic to the degree that they are modified by the additions of various soil-conditioning materials. In constructing golf courses little attention has been given to providing uniform physical structure in each green. The factual information concerning soil physics in this phase of agronomic work is fragmentary. Consequently, *variation* is the biggest factor facing the golf-course superintendent. It necessitates his careful study of all conditions in order that he may do a satisfactory job.

Procedure

In an effort to evaluate some of the physical soil factors in putting-green management. the USGA Green Section in 1947 selected a number of golf courses in several states for study. Selection of the courses was made on the basis of a knowledge of existing conditions. Each superintendent was asked to supply a core of soil from his "worst" green and one from his "best" green. each core to be taken from an area representative of the green. The judgment of the superintendent was the sole basis for the selection.

The soil cores were taken to the full depth of the cup-cutter and were wrapped at once in waxed paper. They were carefully packaged to avoid breakage in transit and were mailed to the USGA Green Section at Beltsville, Md. Upon arrival, determinations of volume weight were made and observations were recorded on "layering" in the profile. Where marked layering was exhibited, the cores were divided and were analyzed as separate samples. Mechanical analyses were completed on 58 samples, representing 37 plugs. The size distribution of particles was obtained by the International Pipette Method of Analysis, using sodium metaphosphate as the dispersing agent.*

The mechanical composition of a soil and the arrangement of the sand, silt and clay particles control its physical behavior. Thin sections of the soil in its natural structure were obtained by a technique of vacuum impregnation with bakelite. The samples were then ground as any rock sample to a thinness that permitted microscopical examination. Photomicrographs were taken of several distinctively different types of structure.

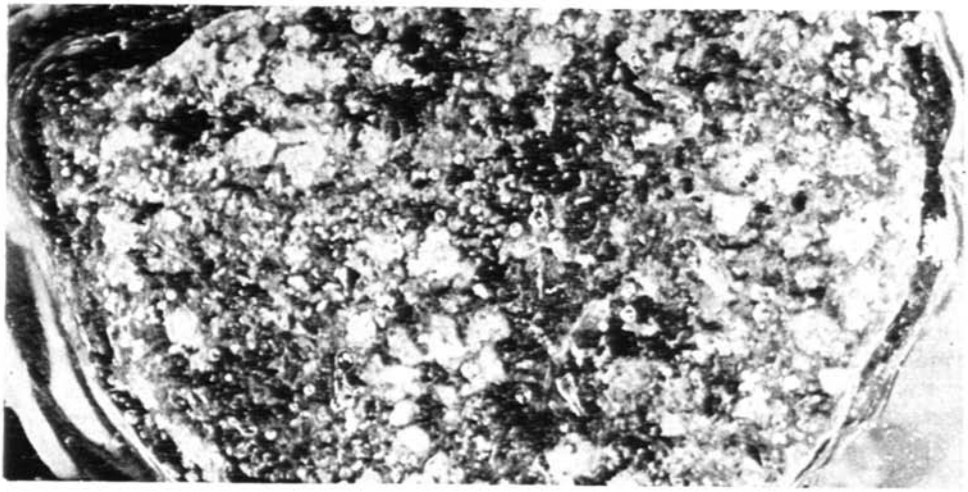
Experimental Results

The extreme individuality of the samples limits the effectiveness of attempting to compare all "good" samples with all "bad" samples. Accordingly, the two samples from each golf course will be compared, and the results will be evaluated in an attempt to discover on how many of the courses the physical soil conditions could be said to be at the root of the trouble. The assumption that all other factors are equal or approximately equal must be made in spite of the fact that they may or may not be identical. Where it is known that other factors are important, it will be so stated in the discussion.

The results of the mechanical analy-

**All mechanical analyses were made at the Saratoga Laboratories, Saratoga Springs, New York, under a research contract with the USGA Green Section.*

Course No. 1. Poor Green



This sample is characterized by a very high proportion of sand which creates a very open pervious structure. There is not enough silt and clay to hold moisture and plant food, necessitating more frequent feeding and watering. A green built on this soil will be firm but will not become compacted.

sis, volume weight and porosity studies are presented in the accompanying tables. Representative photomicrographs likewise are presented in connection with the discussion on the course in question. Figures in parentheses indicate depth in inches of samples taken.

Course No. 1
MECHANICAL ANALYSIS
Per Cent by Weight

	Good (0-4)	Poor (0-4)
Organic matter	2.9	3.9
Gravel	0.4	0.6
Sand	85.0	83.4
Silt	10.6	2.5
Clay	4.4	9.1
Volume weight	1.55	1.65
Porosity	42	38

In this case the "poor" turf appears to be associated with higher organic matter, more sand, less silt and more clay than we find in the "good' green. The higher porosity and the lower volume weight in the "good" green are functions of the greater quantities of silt and clay combined.

It must be recognized that on this course even the green labeled "poor" is always in tournament condition. Thus "good" and "poor" are relative terms, and comparisons can be made only on the same course.

These greens would benefit by having some additional clay and silt incorporated into the sand to increase the ability of the soil to retain moisture and fertility. These are Bermudagrass greens and are noted for their excellence.

Course No. 2
MECHANICAL ANALYSIS
Per Cent By Weight
(0-7 inches; no layering)

	Good	Poor
Organic matter	2.3	1.7
Gravel	0.6	2.2
Sand	21.4	17.8
Silt	60.8	56.5
Clay	17.4	25.7
Volume weight	1.25	1.33
Porosity	53.	50.

The "good" green has a lower volume weight, a higher total porosity, a higher organic-matter content and a lower silt-clay content than the "poor" green. The silt-clay content is so high in both greens that it would seem logical to incorporate sand and organic matter to provide a more open, porous structure and to improve percolation. These soils become very dense and the clay packs tightly around the larger particles, providing no continuous channels for drainage and aeration. The larger, dark particles are concretions, and the dark irregular-shaped particles are fragments of organic matter.

Course No. 3

MECHANICAL ANALYSIS
Per Cent by Weight

Organic matter	2.9	0.9	2.4	0.9
Gravel	0.5	1.9	0.6	3.1
Sand	72.7	70.5	71.3	62.1
Silt	25.2	20.1	20.6	26.1
Clay	2.1	9.4	8.1	11.8
Volume weight	1.37		1.33	
Porosity	48.		50.	

Because of layering, the samples were divided where the cores broke naturally. Looking at the average of the analysis to the 4-inch depth, the "good" green has a higher volume weight, lower porosity, slightly higher organic matter, more sand and less silt and clay than the "poor" green. A reduction in the silt-clay content by incorporating sand and the addition of organic matter would result in improvement of conditions on the poor green.

On this course the difference between "good" and "poor" is small, and it can be attributed to the factor of location as much as to differences in mechanical analysis.

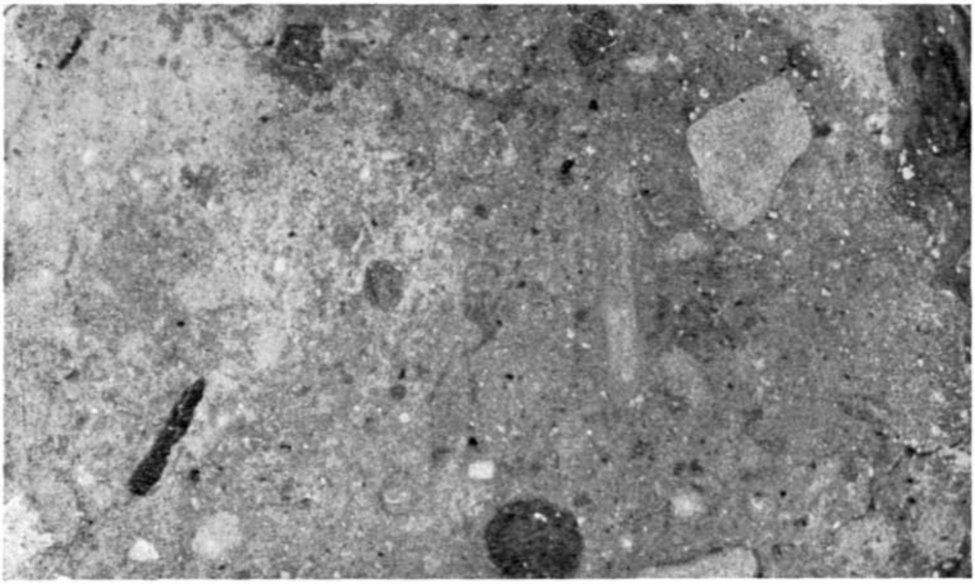
Course No. 4

MECHANICAL ANALYSIS
Per Cent by Weight

	Good	Poor	
	(0-4)	(0-1)	(1-5)
Organic matter	0.6	14.6	2.1
Gravel	3.6	2.2	0.0
Sand	24.8	45.7	5.1
Silt	59.0	43.6	82.7
Clay	16.2	10.7	12.2
Volume weight	1.31	1.58	
Porosity	51	40.	

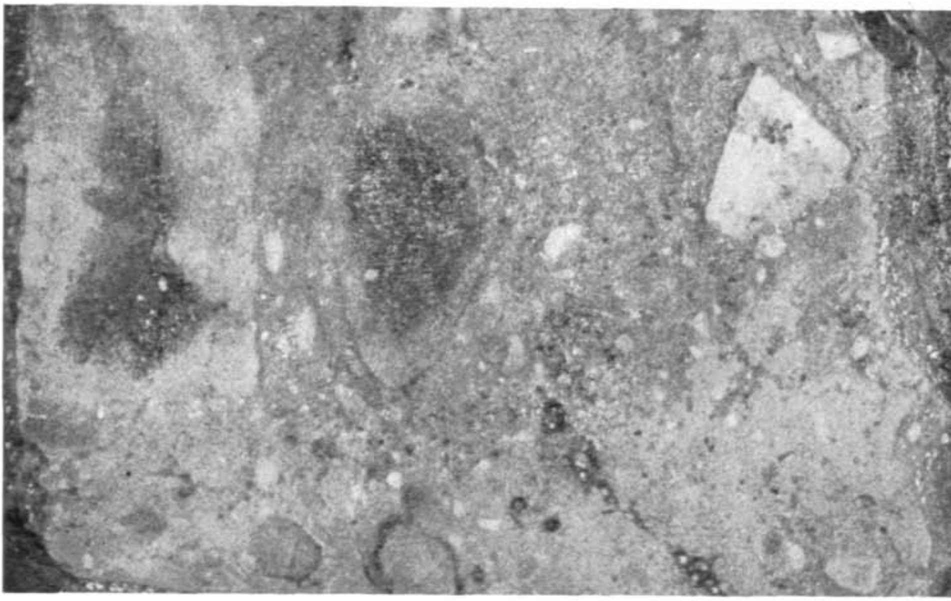
In the "good" green there was no layering, but in the "poor" green the sample broke at the 1-inch depth. The difficulty here is not in total analysis but in the high silt (82.7%) and the low sand content (5.1%) in the 1-5 inch depth of the "poor" green. In this case even the "good" green would be benefited by incorporating sand and organic matter to the full depth (6 inches, if possible). The "poor" green would benefit from frequent deep cultivations, coupled with dressings of high sand content. The high organic matter content (14.6%) in the top inch of the poor green would indicate severe matting and

Course No. 2. Poor Green



The soil is an extremely dense, light-colored silt loam. The gravel particles are too few in number to provide continuous channels for good drainage and proper aeration. The clay is closely packed around the larger particles. There is not enough sand to create a desirable open porous structure. The dark, irregular-shaped particles are fragments of organic matter.

Course No. 5. Poor Green



This represents a gravelly clay soil where the films of clay surround the gravel particles, choking off the larger pores and disrupting water and air movement. Less clay and more sand would re-establish drainage and aeration channels.

the development of conditions favorable to disease organism. The high organic matter would hold moisture, encourage shallow rooting and encourage the development of localized dry spots by preventing the absorption of water into the lower levels.

On this course the physical conditions of the soil are known to be at the root of the trouble.

Course No. 5
MECHANICAL ANALYSIS
Per Cent by Weight

	Good (0-4)	Poor (0-3)	Poor (3-5)
Organic matter	1.0	11.3	7.7
Gravel	2.2	3.5	9.7
Sand	58.3	46.4	37.7
Silt	29.4	41.9	37.6
Clay	12.3	11.7	24.7
Volume weight	1.35		
Porosity	49.		

Here we have a situation similar to Course No. 4, where the surface layer of the "poor" green is exceptionally high in organic matter and where the lower layer (3-5 inches) is exceptionally high in silt and clay. The gravel in the "poor" green is so tightly surrounded by the finer particles that drainage channels are practically nonexistent. Thorough cultivation and incorporation of sand would be extremely beneficial in encouraging deeper rooting.

This comparison is not entirely valid because the "good" green is Bermudagrass, whereas the "poor" green is Metropolitan bent. The failure of the bentgrass can be attributed in part to the physical soil conditions.

Course No. 6
MECHANICAL ANALYSIS
Per Cent by Weight

	Good (0-7)	Poor (0-6)
Organic matter	3.6	3.6
Gravel	3.2	3.7
Sand	57.4	60.0
Silt	24.6	24.5
Clay	18.0	15.5
Volume weight	1.19	1.33
Porosity	55.	50.

In this case the mechanical analyses are so nearly alike that we must look elsewhere for the difficulty. The volume weight in the "poor" green is much higher and the porosity much lower than in the "good" green. It must be pointed out in this case that the "good" green gave only slightly less trouble than the "poor" green and that there has been great difficulty on all the greens.

Course No. 7

MECHANICAL ANALYSIS

Per Cent by Weight

	Good	Poor	
	(0-6)	(0-2)	(2-5)
Organic matter	2.3	6.7	0.9
Gravel	1.9	0.9	0.4
Sand	58.7	64.1	13.0
Silt	39.4	29.0	56.6
Clay	1.9	6.9	30.4
Volume weight	1.55	1.40	
Porosity	42.	47.	

This course is located on soils that are renowned for their high clay content. The "good" green shows a rather high proportion of silt but, because the profile is uniform, it was possible to maintain a good turf by adjusting management practices. In the "poor" green we find a high content of organic matter in the 0-2 inch level and a very high percentage of silt and clay in the 2-5 inch level, which effectively retards drainage and aeration. An attempt was made to incorporate sand, which shows in the 0-2 inch level, but it has been ineffective because there has been no mixing. The layering has prevented root growth beyond the 2-inch level.

Course No. 8

MECHANICAL ANALYSIS

Per Cent by Weight

	Good	Poor	
	(0-1)	(1-3)	(0-2)
Organic matter	5.1	5.8	5.9
Gravel	0.2	0.2	0.2
Sand	81.6	80.3	72.8
Silt	7.0	7.3	15.4
Clay	11.4	12.4	11.8
Volume weight		0.93	1.08
Porosity		65.	59.

The "poor" green here seems to be associated with a higher silt-plus-clay content than the "good" green. This difference, with the higher volume weight which indicates compaction, and the lower porosity, which indicates poor aeration, could account for the difference. This course has a high water table and drainage generally is known to be poor. These greens had very high proportions of medium and fine sand and only small amounts of coarse sand and fine gravel.

Course No. 9

MECHANICAL ANALYSIS

Per Cent by Weight

	Good		Poor	
	(0-3)	(3-6)	(0-1)	(1-5)
Organic matter	3.1	0.9	5.8	1.4
Gravel	2.0	2.0	2.7	4.5
Sand	58.2	40.0	61.2	47.5
Silt	31.7	46.6	20.8	43.2
Clay	10.1	13.4	18.0	9.3
Volume weight	1.11		1.16	
Porosity	58.		58.	
	(0-2)	(2-4)	(0-2)	(2-4)
Organic matter	3.3	2.8	2.0	1.7
Gravel	2.3	3.6	1.1	9.5
Sand	61.7	53.6	61.0	69.3
Silt	27.1	29.3	30.0	21.2
Clay	11.2	17.1	9.0	9.5
Volume weight	1.12		1.20	
Porosity	58.		55.	

It is extremely difficult to discover any logical basis in these analyses for the designations "good" and "poor" for these samples. The "poor" greens are higher in volume weight but are only slightly different. The "poor" greens are lower in porosity but the difference again is slight. The bad layering on all these greens makes interpretation extremely difficult when the other unknown factors cannot be evaluated. In this case we are forced to say that the "poor" greens are poorer than the "good" greens for reasons other than physical soil conditions.

Course No. 10

MECHANICAL ANALYSIS

Per Cent by Weight

	Good	Poor
	(0-6)	(0-6)
Organic matter	3.7	3.6
Gravel	1.2	0.5
Sand	46.5	54.9
Silt	36.4	35.8
Clay	17.1	9.3
Volume weight	1.38	1.40
Porosity	48.	47.

No striking differences exist here, and it is interesting that the "poor" green actually contains more sand in the 0-6 inch level than the "good" green. The "poor" green in this case is poor because of location on the edge of a lake, whereas the "good" green is higher and is open and well-drained. This is a case where the difference cannot be ascribed on the basis of soil physics.

Course No. 11
MECHANICAL ANALYSIS
Per Cent by Weight

	Good		Poor	
	(0-2½)	(2 ½-6)	(0-4)	(4-6)
Organic matter	7.1	3.0	6.7	0.0
Gravel	0.5	5.2	0.1	7.3
Sand	73.5	52.8	76.2	65.2
Silt	5.3	23.0	14.4	21.1
Clay	21.2	19.2	9.4	13.7
Volume weight	1.39		1.33	
Porosity	48.		50.	

This case is similar to No. 10. There is some layering, but it exists in both classifications. The complete absence of organic matter in the 4-6 inch level of the "poor" green could be a deciding factor. This course is on soil that is famed for its sticky, gumbo-type clay. It is likely that the reason for the designations must be sought elsewhere. All of the greens on this course are famed for their excellence, and any differences are known to be slight.

Course No. 12
MECHANICAL ANALYSIS
Per Cent by Weight

	Good		Poor
	(0-1)	(1-4)	(0-4)
Organic matter	3.9	2.3	1.9
Gravel	0.1	0.2	1.0
Sand	61.4	55.5	47.1
Silt	28.4	34.8	40.3
Clay	10.2	9.7	12.6
Volume weight	1.19		1.25
Porosity	55.		53.

In the "poor" green the lower organic matter and the higher silt and clay content contribute to a higher volume weight (density) and lower porosity. The "poor" green is at a streamside surrounded by trees, and the air drainage is poor. The green is small and traffic is heavy. The "good" green occupies a more favorable location in addition to having a better physical soil makeup. Even though the differences in the mechanical analysis are not large, they are important when other unfavorable factors are added.

Course No. 13
MECHANICAL ANALYSIS
Per Cent by Weight

	Good		Poor
	(0-3)	(3-6)	(0-7)
Organic matter	2.9	6.3	9.8
Gravel	0.4	1.9	2.5
Sand	62.3	63.9	69.9
Silt	27.1	22.6	16.4
Clay	10.6	13.5	13.7
Volume weight	1.37		1.41
Porosity	48.		47.

The most striking difference that is shown by these analyses is the very high organic-matter content in the 0.7 inch layer of the "poor" green, which actually has more sand than the "good" green. In spite of the high organic-matter content the volume weight of the "poor" green is higher, which is indicative of greater compaction. The "good" green is on a hillside in the open, with no trees near it. The "poor" green is a smaller green (which gets the same total traffic), it is low, entirely surrounded by trees and is a seeded green; whereas the "good" green was vegetated to Washington bent.

Course No. 14
MECHANICAL ANALYSIS
Per Cent by Weight

	Good		Poor	
	(0-2)	(2-4)	(0-2)	(2-4)
Organic matter	1.3	2.6	2.7	1.8
Gravel	0.9	0.9	4.6	6.5
Sand	63.5	65.2	64.9	61.2
Silt	18.0	20.2	21.5	21.2
Clay	18.5	14.6	13.6	17.6
Volume weight	0.94		1.15	
Porosity	65.		57.	

These analyses are marked for their uniformity, especially in the sand content. The higher volume weight and gravel content and the lower porosity may in part account for the difference in designation, but other factors are suspected to be more important as in the case of Course No. 13.

Course No. 15
MECHANICAL ANALYSIS
Per Cent by Weight

Organic matter	8.0	1.0
Gravel	0.0	0.6
Sand	73.2	45.4
Silt	18.8	43.9
Clay	8.0	10.7
Volume weight	1.30	
Porosity	51.	

This single "good" green is given here because it represents a good green from many standpoints. We cannot say that the soil conditions are ideal, but the soil supports a turf that is nearly perfect from the playing standpoint. Careful management is the rule on this course. It is interesting that the volume weight of 1.30 is about midway between the mean volume weight of the "good" greens (1.22) and the volume weight of the "poor" greens (1.34). Likewise the porosity (51) is between the mean of the "good" greens (53.4) and the mean of the "poor" greens (49.9).

(Continued in next issue)

QUESTIONS AND ANSWERS

The answers below are in reply to actual questions received by the Green Section staff in correspondence or at turf conferences and meetings. In some cases the question has been rephrased. Since the authorship of many questions received at meetings is in doubt, reference to location are omitted.

QUESTION—What advantages does B-27 bluegrass have over commercial bluegrass seed? When will B-27 seed be available on the market and what will it cost?

ANSWER—B-27 bluegrass is lower growing, will withstand closer mowing, is more resistant to *Helminthosporium* leafspot and maintains a turf of pleasing color with greater freedom from weeds than does commercial Kentucky bluegrass. There is evidence that it is somewhat more heat tolerant and drought tolerant than is common bluegrass. Cooperative tests in progress will decide some of these points.

Seed should be available commercially in reasonable supply in two years. Acreage increase for seed production is expanding rapidly. Most of the seed will be produced in Oregon.

The cost of B-27 bluegrass will be much higher; it may sell at four to five times the price of common bluegrass. It is expected that less seed will be required to produce good turf. Establishment is more rapid and seedling vigor is greater than with common bluegrass.

QUESTION—We have read in the Agronomy Journal and in the USGA JOURNAL that the Turf Committee of the American Society of Agronomy has recommended that Highland bent be substituted in turf-seed mixtures for redtop. What are the reasons for the change and what are the advantages of Highland bent over redtop?

ANSWER—Highland bent is a close relative of redtop, but it has the advantage of producing a turf of more pleasing texture and color. It becomes a permanent part of the turf, but it acts as a nurse grass by germinating quickly, as redtop does. Highland bent is available in quantity, whereas redtop has been scarce and high in price because of seed-crop failures.

Highland bent is less competitive than redtop when included in turf seed mixtures because it grows less coarse and less rapidly. Highland bent produces excellent turf when seeded by itself on golf-course fairways or when included in lawn, tee and even athletic-field mixtures. Its use in athletic-field mixtures thus far has been confined largely to the Pacific Northwest, where it is used in combination with Alta fescue.

Because of its smaller seed size, three-fourths of a pound of Highland bent can be substituted for one pound of redtop. In a mixture with bluegrass, red fescue, or Alta fescue, Highland bent generally need not exceed 20 per cent of the mixture by weight.

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