Another reason for sowing a variety of grasses in a green (and this fact is appreciated by very few people) is that some of the grasses are very slow in maturing while others are in their prime during the first year. For example, the very finest of all grasses for making a putting green in a moderately warm climate, creeping bent (*Agrostis stolonifera*), as *ordinarily planted* requires from three to eight years before it reaches the full stage of development in which it represents almost the ideal putting green grass; and in the meantime some other grass is needed to cover the green properly while the creeping bent is in process of development.

For three years he followed, not only what experts considered the best general methods of preparing the soil and selecting and sowing the seeds, but also what they considered the best general methods of caring for and treating the growing grass. But though we may be sure he followed their methods with rare intelligence, each of the three years brought him a disappointment. At first he attributed his lack of success to not having the right manure and fertilizer, and to a failure to water properly.

For several years [says Van du Zee] Dr. Taylor worked with all his ingenuity to make the green a success. The injured places were cut out and refilled with a different soil, then seeded with much care. At another time when the grass seemed below par, holes were punched with a steel dibble and filled with bone meal, topped with a germinating mixture. Other carefully thought out efforts were made to get good grass. All these efforts were carefully watched, but the watching did not help.[1]

It should be understood that Taylor was using only the seeds of the "finer, more delicate grasses suitable for a putting green." Eventually he was made to realize that the principal cause of his failure was his "good rich garden soil," which was "unsuitable for growing fine grass, because its grain composition did not permit the grass roots to penetrate as they should, and because its moisture-holding properties were wrong." This fact, however, he had to learn through his own experiments. At the end of the three-year period he found that none of the knowledge of grass-growing then existing was of any service in meeting his problem. He wanted a first-class putting green within a comparatively short time, and the general opinion was that it was impossible. Ah, yes, it was impossible. So, of course, he set out with deliberation to get it.

As is frequently the case [he wrote], what at first started with a few simple experiments opened out finally into quite an extensive investigation, covering many elements, the relative importance of which it would have been difficult for anyone to foresee at the start.

It was an investigation that was carried on for about eight years, or from about 1907 until the time of his death in 1915. In a note prefacing his *Country Life* article, he said:

Through the whole series of experiments leading up to the preparation of this article, the writer has had the constant co-operation of his friends, Robert Bender and Harold Van du Zee. Without their untiring assistance and work the investigation could not have been carried on. In his writing, therefore, the author stands as the representative of all three.

It was Taylor who directed and supervised the course of the experiments, and furnished the inspiration. It was Bender who, besides contributing his knowledge as an expert gardener, directed the work of the men who performed the manual labor. During Taylor's lifetime about six men were employed to assist Bender with the regular grounds and garden work, but they had nothing to do with the grass-growing experiments. For these experiments Bender had a special force that from time to time ranged between ten and thirty. As for Van du Zee, it was he who laid out the plans of a civil engineering nature, had charge of the seed-germinating and soil tests, and kept the records.

While the writer must confess [Taylor added] that his principal reason for making these experiments was the pleasure which he derived from the investigation, still, as time went on, and useful results were attained, there came the secondary object of trying to help the golfers of the country to get better putting greens.

As a matter of fact, it was his desire to make his experiments of general service that directly accounts for the scale on which he came to conduct them. We read further:

Our experiments started in a somewhat desultory way by planting grass seeds in different soils. We soon realized, however, that if the results obtained by us were to be of real use to grass growers outside of the neighborhood of Philadelphia, there was little to be gained by experimenting with natural soils.

It is practically impossible to describe a natural soil so that it can be duplicated in another part of the country. Soils which have been in process of formation for thousands of years are, in most cases, so intricate in their grain composition, their organic and inorganic food contents, their moisture-holding properties, and their penetrability by grass roots, that it is impossible to describe them so that they can be duplicated.

The words "good sandy loam" and "rich clay soil," for instance, are entirely inadequate to indicate whether a soil is suited to growing grass or not. We, therefore, decided to experiment only with soils artificially made by mixing together elementary materials which can be procured in all parts of the world. . . .

Our experiments had not proceeded very far before we reached the conclusion that a putting green could be constructed of materials of this sort, so that a single variety of grass could be made to grow perfectly on all parts of the green, thus securing a degree of uniformity in the resistance of the grass to the ball which was impossible when, as under the old system, several kinds of grass are planted on the same green. In other words, we proposed to find out the particular variety of grass which will produce the finest and best surface for a putting green, and then develop an artificial soil especially suited to growing this grass. Our object became to suit the soil to the grass, not the grass to the soil.

This means that, to make his grass-growing experiments yield results that would be generally useful, he again had to resort to his principle of standardization.

[1] Paper prepared by Van du Zee for Memorial Meeting at Boxly.

His experiments, in fine, naturally resolved themselves into a search for a standard grass and a standard soil in which to grow it. How thorough he made them will appear from this list, taken from his *Country Life* article, of the subjects he set down for investigation:

1. How to germinate the seeds.
2. The proper number of spears per square inch which should be germinated in order to devlop grass quickly.
3. How to develop the young grass plants with greatest rapidity.
4. Kind of soil in which the old roots will thrive best.
5. Kind of grasses best for making greens.
6. Nature and amount of food used in soil.
7. How to water.
8. How to mow grass. How soon and at what height.
9. How to keep out weeds.
10. How to promote rapid deep rooting.
11. Soft but firm surface on which ball will bite right in wet or dry weather.
12. Effect of adding cover of different kinds.
13. How to prevent mildew.
14. Rolling, reason for and kind of.
15. Worms—how to prevent them.
16. The causes for sour soil, and remedies.
17. How soil should be packed in placing a green—loose and tight packing.
18. Best and most economical methods of preparing, mixing, and placing the materials used in making a green, including study of best apparatus to use for this purpose.
19. The most favorable time of the year for planting seeds.
20. How best to guard against the ravages of a heavy rain storm coming soon after green is planted.
21. Kind of food to add to older grasses—when and how to feed it. (See 6.)
22. Worm casts.
23. Depth of soil necessary.

The first seven of these subjects have called for the larger part of our study and attention, and of these the investigation of the conditions under which old grass roots thrive best has taken the most time—chiefly, of course, because it was necessary to wait, in most cases, about nine months for the grass to mature before definite conclusions could be reached. It will be appreciated, of course, that many of these elements are so interdependent that a study of one subject must, of necessity, be closely associated with several others.

One of the first principles governing all scientific investigation, however, is that each experiment shall involve only one single change or innovation. And this simple rule has been closely followed by us, although it has, of course, called for a large number of experiments.[1]

We also may quote in part what he wrote of the general methods to which after two years of "rather desultory" experimenting, due to his inability immediately to grasp the problem in all its ramifications, he eventually settled down:

Small plots of the different soils, whose grass growing properties were to be investigated, were placed side by side in beds so that a glance from one plot to another would detect even small differences in the quality of the grass. The grass on these plots was all treated in the best possible way so as to bring it to the greatest state of perfection before the intense heat of the summer began to cause it to deteriorate.

Having perfected our grass, in order to prove which plot was the best, it was necessary to subject all of them to the most severe conditions to which grass is likely to be submitted by nature; and, as the grass gradually deteriorated under this severe treatment, to note those plots which showed the greatest resistance to adverse conditions.

It is only by subjecting two or more plots of grass to severe and unfavorable conditions that it is possible to definitely decide which is the best. If they are well treated they are all alike.

The two most severe conditions to which grass is subjected by nature is a combination of great heat with drought, or great heat with an excess of moisture. The climate of Philadelphia, owing to its intense summer heat, is therefore especially favorable for making grass experiments. It would be difficult, in fact, if not impossible, in a cool summer climate to successfully conduct grass experiments. . . .

Between the fifteenth of September and the first of November of each year, from 100 to 450 small plots of soil were prepared and sowed with grass seed. For several years past we have adopted 2 x 2 ft. as the standard size of a plot.

Each of these plots contained only one element, affecting the growth of the grass, which we wished to investigate. They were all sowed with red fescue (*Festuca rubra*) seed because, while among dwarf grasses red fescue is one of the finest and most virile in a cold climate, in a hot climate (like that of Philadelphia) it is almost impossible to make this variety of grass live through the summer months if sowed in any ordinary soil; and a grass of this sort (difficult to grow) is needed to emphasize the differences in the soils under investigation.

Our experiments for several years were made in duplicate; one group of plots containing the various soils to be tested being placed in one part of our grass garden, while a second group of exactly similar plots was located at some distance from the first. . . .

From the time the seeds were planted until the following fall, accurate records were kept of all important facts connected with the growth and decline of the grass.

In the paper Van du Zee read at the Memorial Meeting we find some interesting side-lights on these experiments in general:

I shall never forget from what a simple statement of basis grew up an unfinished work covering several years of unceasing effort. Dr. Taylor's first explanation to Mr. Bender and myself was that grass needs nourishment, root space, air, and moisture—and for the best meeting of these four requirements were carried out many hundreds of growing tests, and thousands of tests of materials, relating to their physical properties, source, cost, etc.

Many of the materials used in the tests were found only after

[1] This grass-growing investigation may be taken as exemplifying in its thoroughness all the investigating done by Taylor in determining standards. How, on the other hand, an "efficiency engineer" gets his standards is strikingly exemplified by the remarks on potato growing made by Harrington Emerson in his chapter on "Standards" in his book *Efficiency*. "What," says Mr. Emerson, "is the limit of yield of potatoes from an acre of ground in the United States? The average yield per acre over a series of years is 96 bushels. Shall we, therefore, set 100 bushels as standard 100 per cent efficiency? The lowest average in 1907, 65 bushels, occurred in the great agricultural State of Kansas; the highest average was in the desert State of Wyoming, 200 bushels to the acre. The highest average in Wyoming is due to one man, who issued a challenge of $1,000 open to all the potato growers of Colorado, that he would raise on his Wyoming farm more potatoes per acre than anyone could raise in Colorado, provided further that if he won the contest yet failed to raise 1,000 bushels per acre, he would forfeit the whole of the stakes, $2,000, to charity. He won. It is psychology, not soil or climate, that enables a man to raise five times as many potatoes per acre as the average of his own State, ten times as many per acre as the average of the United States, thirteen times as many as the average in the better soil and climate of Kansas. An easily attainable standard of potato raising is therefore not 100 bushels but 500 bushels, which can be called 100 per cent efficiency."