himself, urged close, thoughtful reading of golf business literature.

In advising on greens building today he said:

After the location is selected, plow the surface and remove topsoil. Then remove all stones to a depth of at least 12 ins. Lay sufficient drainage to a depth of approximately 24 ins., using 4- to 6-in. land tile, about 15 ft. apart, laid with the fall of the land. It is best to cover the tile with burlap bags or a 2-in. layer of straw, refill trench, proceed to build up the green to about an 8-in. depth in the lowest level. This soil should be first-class topsoil. In grading the slope of the green to hold a shot, the back of the green should be not less than 16 ins. nor more than 24 ins. higher than the front. This will take care of the surface water. Countouring is very important; this should not be abrupt, but gently sloping and irregular in shape. Cover with about 4 ins. of good topsoil and 2 ins. of compost, mixed with arsenate of lead at the rate of about 6 lbs. to 1,000 sq. ft., to grubproof the green. Rake and roll until a fine seed-bed is completed. Then plant seeds or stolons. Greens built this way are cheaper to maintain and are less liable to develop brown-patch or scald. Good drainage is the foundation of a good putting green.

Campbell's concluding comment was:

Usually when the finance committee starts looking for a place to reduce club expenses, it starts with greens maintenance budget. This does more damage in one year than the greenkeeper can repair in four. Any greenkeeper is anxious to cut costs as far as practical and wants cooperation of the finance committee and green-chairman to this end.

Factors Affecting Accumulation of Nitrates in Soil

By M. H. CUBBON

Prof., Massachusetts State College

NATURE PUT many varieties of bacteria into soil, each to do a rather particular job. Certain organisms work on one type of organic matter, others on different types. Products which one group discards as waste materials another group requires as food.

When organic matter is decayed by soil organisms it produces simple substances, mostly gases. Of these gases the one that concerns us most is ammonia. Regardless of how complex the organic matter may be, the nitrogen in it ultimately reaches the ammonia condition. As many as a dozen different groups of organisms in soil produce ammonia from organic nitrogen. Thus if one group happens to be indisposed another is there to do the work.

Plants normally cannot use nitrogen as ammonia, hence it must be changed to a usable form—nitrate nitrogen. Nitrates are produced from ammonia by a process of oxidation by two groups of bacteria. If conditions are unfavorable to them the production of nitrates must stop, because there are no other organisms to do this particular job. And like many skilled workmen, they are quite particular about the conditions under which they labor.

In the case of nitrate bacteria the soil must not be too wet nor too acid nor too cold. Nature usually has soils that are quite acid, and very often wet and cold, yet plants are expected to find the nitrates they need. In the case of greens, man often makes conditions worse instead of better, unintentionally of course.

Let us look more into the details of the requirements for nitrate production in soil. Since the process is one of oxidation plenty of oxygen must be present. Packed or wet soil has little and sometimes no air (oxygen) space. Heavy soils (silts, clays, loams) are the ones that pack worst. The remedy is to incorporate sand, organic matter, or any material which will loosen the soil. Packing is much worse when soil is wet. Packing due to persons walking over greens is much more severe than the rolling the greens normally get.

Ordinary temperatures are satisfactory for the production of nitrates. By ordinary is meant above 60° F. Acid soils require somewhat higher temperatures than 60°, while neutral soils are able to produce considerable nitrates as low as 50°. This may account for a difference in starting time in spring.

What Does "pH" Mean?

The most important single factor in the production of nitrates is soil acidity, expressed in terms of pH value. pH7 is neutral, and any pH value less than 7 is acid. The smaller the number expressing pH value, the more acid the soil. pH4 is more acid than pH5. Soils rarely get below pH4. pH5 is too much acid for most plants. pH6 is perhaps a little too high for the best greens conditions, everything considered. In most soils, bacteria do not produce nitrates when the acidity is stronger than pH5. Considerable variation among soils occurs and in some cases exceptions do happen. This is typical of the complex conditions found in soils. If there were no variables the science of fertilizing soils would soon become exact. As it is, nobody can put his finger definitely on some of the problems confronting us.

The amount of nitrate accumulating in the soil from organic fertilizers and materials depends pretty largely on the ratio between nitrogen and carbon. If too much carbon is present in proportion to the nitrogen, nitrates do not appear in the soil for some time after adding the organic material. Organic materials with less than 4% nitrogen usually produce this absence of nitrates. Peat moss comes in this class. Many times it has tended to give poor results, which could have been avoided if a little nitrogen had been added with the peat. After the bacteria have worked on the organic material and have largely decayed it, some nitrate has a chance to accumulate. These so-called toxic effects of peat are therefore only a shortage of nitrogen because the bacteria that decay the peat take nitrogen away from the plants.

Test Nitrogen Availability

The question of how quickly organic nitrogen fertilizers become available can be partly answered as follows: nitrate accumulation from organic nitrogen sources is closely related to the amount of water soluble nitrogen in the organic material. In the case of cottonseed meal compared with dried blood on soil 3 (Massachusetts) you will notice (see table) that cottonseed accumulated nitrates faster than did dried blood. The water soluble nitrogen in each fertilizer is practically the same, but the proportion of water soluble nitrogen in cottonseed meal to total nitrogen is much higher than in dried blood. Again exceptions occur in this respect, but it is

Nitrate Accumulation, Massachusetts Soils

Soil No. 1—Fertile, sandy loam. pH value 6.12. 8 milligrams nitrogen added from various substances.

Source of nitrogen.	Per cent nitrogen changed to nitrate in 4 days	6 days	10 days	14 days	22 days
Cottonseed meal	0	.7	0	21.2	16.5
Castor pomace	0	8.5	13.7	22.9	15.0
Urea	4.8	16.1	48.1	88.2	114.2
Dried blood	2.03	0	33.6	68.2	114.2
Milorganite	9.1	18.1	45.0	27.9	55.0
Grass clippings	13.0	31.6	45.5	33.7	44.2
Ammonium sulphate	0	.7	38.5	79.8	111.3
Ammonium sulphate plus 23 lbs. limestone per 1,000 ft.	0	2.0	53.5	88.2	79.5
Liquid ammonia	0	4.8	54.9	107.4	111.3

Soil No. 2—Infertile sandy loam. pH value of soil was 5.3, and with lime added, 6.05. Other conditions same as above.

Source of nitrogen.	Percent nitrogen changed to nitrate in 4 days	6 days	10 days	14 days	17 days	22 days
Cottonseed meal	0	0	0	0	2.0	3.3
Castor pomace	1.0	1.6	2.0	.8	3.1	5.1
Urea	0	0	0	1.0	4.0	18.5
Dried blood	0	0	.8	0	1.0	2.7
Milorganite	0	1.4	.7	0	1.3	3.5
Grass clippings	1.0	.8	.9	0	2.8	13.7
Ammonium sulphate	0	0	0	0	0	0
Ammonium sulphate plus 92 lbs. limestone per 1,000 ft.	1.9	1.3	4.1	6.4	18.7	62.4
Liquid ammonia	0	0	0	1.1	7.0	22.3

Soil No. 3—Fairly fertile sandy loam. pH value 6.0.

Source of nitrogen.	Percent nitrogen changed to nitrate after 12 days	14 days	16 days	18 days	21 days	24 days	30 days
Cottonseed meal	0	0	2.05	6.4	4.5	8.9	5.9
Castor pomace	.4	2.6	10.8	19.6	28.6	26.7	31.1
Urea	1.2	1.2	15.3	12.6	34.5	43.4	46.7
Dried blood	0	.6	9.19	13.5	27.4	26.7	32.3
Milorganite	2.56	2.49	7.66	14.1	23.4	25.4	34.0
Grass clppings	6.37	8.77	17.1	23.8	38.2	36.9	46.7
Ammonium sulphate	0	0	0	0	0	0	6.3

In this experiment 30 mgms. nitrogen added per 100 gms. soil. Such a large amount of nitrogen probably accounts for poor showing of sulphate of ammonia. Behavior of grass clippings indicates they have considerable value as source of nitrogen.

Nitrate Accumulation, Iowa Soils (Harper)

Description of soil.	Mgms. of nitrogen added per 100 gms. soil.	Per cent nitrogen changed to nitrate after 10 days	15 days	20 days	28 days
Basic silt loam	10	72	82	88	94
	30	33	53	70	92
Neutral fine sandy loam	10	55	86	90	109
	30	14	32	53	71
Medium acid loam	10	31	53	63	97
	30	10	18	22	39

Nitrate Accumulation, Alabama Soils (Naftel)

	pH values.	% nitrogen changed to nitrate after 10 days	20 days	30 days
Soil No. 1	5.2	15	32	66
	5.6	66	93	100
Soil No. 2	5.9	42	..	..
	6.2	91	..	..
Soil No. 3	5.6	33	..	..
	6.8	96	..	..

In this experiment 4 mgms. nitrogen were added per 100 grams of soil. In both experiments nitrogen was supplied as sulphate of ammonia.

Nitrate Accumulation, Wooster (Ohio) Silt Loam Soil (Bear)

Source of nitrogen.	% nitrogen changed to nitrate after 21 days with varying moisture in soil. 23 % water in soil	28	33	38
Sulphate of ammonia	112	118	93	27
Nitrate of soda	110	115	91	54
Dried blood	82	81	61	7
Cottonseed meal	69	69	43	5
Activated sludge	66	66	60	4
Alfalfa hay	60	62	56	6
Muck	39	39	39	5
Garbage tankage	26	28	20	5
Calcium cyanamid	7	6	6	5
Horse manure	4	4	3	4

This soil made neutral by adding lime. 20 mgms. nitrogen added per 100 gms. soil.

fairly safe to say that nitrate nitrogen accumulated from organic materials practically in proportion to the amount of water soluble nitrogen contained.

The rapidity with which nitrate nitrogen accumulates in soil is the best single measurement for the productivity of that soil. In making controlled experiments it is the common practice to add to soil some nitrogenous fertilizer such as sulphate of ammonia, keep the soil at favorable moisture and temperature for a time, and then determine the amount of nitrate in the soil. In the tables, summaries of experiments in which nitrate accumulation was studied are given. This accumulation is stated as a percent of the original nitrogen added to the soil. The important thing in all tables except the last is the time factor. Several things in these tables may be mentioned as outstanding.

First, the acidity of soil 2 (Massachusetts) had definitely prevented the accumulation of nitrate nitrogen without lime added. Even when liquid ammonia was added the neutralizing effect was not enough to induce the accumulation of nitrates. The lime added with sulphate of ammonia was thoroughly mixed with the soil, yet in spite of this mixing nitrates did not accumulate for some time. How much longer would it require for lime, applied as a top-dressing and inadequately mixed with the soil, to give a response in terms of nitrates produced?

Second, manure should be considered as typical of the materials with a low nitrogen and high carbon content. The behavior as regards nitrate accumulation is also typical. Very little nitrates are produced, or at least accumulated, and if plants were growing on the soil they would undoubtedly suffer from lack of nitrogen. Garbage tankage behaves similarly. Other tests have shown that the nitrogen availability in garbage tankage is very low.

Third, the effect of too much water in soil in the experiment by Baer is plainly evident. The 38% water content is probably higher than most soils can carry under playing conditions. No doubt the available nitrogen in many greens is lost because of poor drainage, and occasionally because of over-watering. Even when nitrates are added to the soil as nitrate of soda or similar material, the nitrates disappear under the influence of too much water.

Illustrated Lecture on Turf Diseases

By JOHN MONTIETH, JR.

USGA Green Section

DR. JOHN MONTEITH, JR., USGA Green Section, presented an illustrated lecture on turf diseases that was especially helpful because of the clear, colored slides with which this noted expert brought out vivid details of his remarks.

He identified turf diseases as being of two types: (1) caused by invasion of disease organism, and (2) caused by other conditions affecting growth of the plant. The principal cause of disease in humans is bacteria; in plants, fungi. Dr. Monteith showed a vastly enlarged cross-section of a blade of grass and pointed out how diseases hit the cells of grass. Other enlarged cross-sections showed progress of fungus penetrating grass through pores in the blades. He went into this in detail to explain how extensive microscopic investigations had confirmed the fungus theory of brown-patch.

Monteith counseled his hearers to be extremely careful when diagnosing grass diseases, saying that especially during the troubles of last year greenkeepers were apt to make the mistake of treating for diseases that didn't exist. He showed pictures of disease organisms growing in cultures and went to pains to show his practical audience how the scientists let nature confirm or damn the theories.

Pictures of plots on which mercury treatments were tested were shown and many interesting developments of the patient, extensive work done by the turf scientists in attempting to aid the men in the field were put on the screen.

Comment was made on slides showing effect of lime and air current in preventing brown-patch.

In discussing pythium, Monteith emphasized that the disease develops most at high temperature, hence the prevalence of that trouble during 1931.

Showing slides of snow-mold, the USGA scientist warned that the mild winter might be responsible for severe attacks of this disease. Late growth of grass and lack of freezing, followed by sudden cold weather and snow, makes a perfect setting for development of snow-mold, he stated. Bichloride of mercury and calomel treatments have demonstrated effectiveness against this disease. He presented slides of leaf spot and expressed regret that no satisfactory treatment for leaf spot had been discovered.

Slides of fairy ring, ring spot, mildew, smut, chemical burns and scald also were shown. Fairy ring cure was requested by several at the conference and Monteith said that although definite cases of fairy ring had been under observation for many years no certain cure had been discovered.