Nitrogen—What Is It?

Factors Affecting the Accumulation of Nitrate Nitrogen in Soil

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Read at the 6th Annual Educational Conference of the National Association of Greenkeepers of America, held at New York City, January 19-22.

NATURE has put bacteria into soil in many different varieties and kinds, each to do a rather particular job. There are certain organisms which work on one type of organic matter, and others for different types. There is a division of labor; the products which one group discards as waste materials another group requires as food.

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Who has made a close study of soil conditions and the action of bacteria in the growth of fine turf.

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. Nature has generously provided for a plentiful supply of ammonia.

Plants normally cannot use nitrogen as ammonia, hence it must be changed to a usable form. This form happens to be nitrate nitrogen. Nitrates are produced from ammonia by a process of oxidation by two groups of bacteria. Such bacteria are specialized workers. If conditions are unfavorable to them the production of nitrates must stop because there are no other organisms to do this particular job.

NITRATE BACTERIA ARE SKILLED WORKMEN

LIKE many skilled workmen, nitrate bacteria are quite particular about the conditions under which they labor. The soil must neither 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. Soil that is packed or wet has little and sometimes no air (oxygen) space. Plants growing on wet soil often show yellow leaves and look sickly, largely because they cannot get the nitrogen needed. When forced to do so by conditions, bacteria can take the oxygen away from nitrate and use it to support themselves, and, of course, plants suffer because the nitrogen is no longer available. In most cases the harm done by a wet soil is indirect rather than direct, but this does not prevent it from being serious.

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 which 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

NEXT MONTH

In the April issue of the NATIONAL GREENKEEPER, several interesting papers read at the New York Educational Conference will be published, among them being, "The Care of Trees," by Homer L. Jacobs—"Soil Structure of Putting Greens," by Kenneth Welton—and "Economy on the Golf Course," by John Quaill.

produce considerable nitrates as low as 50°. This may account for a difference in starting time in spring.

SOIL ACIDITY IS IMPORTANT FACTOR

By far the most important single factor in the production of nitrates is the soil acidity. Acidity is expressed in terms of pH value, confusing though the term may be. pH 7 is neutral, and any pH value less than 7 is acid. The smaller the number expressing pH value, the greater the acidity, or the more acid the soil. pH 4 is therefore more acid than pH 5. Soils rarely get below pH 4, while pH 5 is too much acid for most plants. pH 6 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 pH 5. 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 sometime 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 which decay the peat take nitrogen away from the plants.

AVAILABILITY OF ORGANIC NITROGEN FERTILIZERS

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 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 fairly safe to say that nitrate nitrogen accumulates 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 we have 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 following are given summaries of experiments in which nitrate accumulation was studied. This accumulation is stated as a per cent of the original nitrogen added to the soil. The important thing in all tables except the last is the time factor.

Nitrate Accumulation

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 In Alabama Soils

	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 In Massachusetts

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	44.7

Sulphate of ammonia	0	.7	38.5	79.8	111.3
Sulphate of ammonia plus 23 lbs. limestone per thousand feet	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	Per cent 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
Sulphate of ammonia	0	0	0	0	0	0
Sulphate of ammonia plus 92 lbs. limestone per thousand feet	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.

	Per cent 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 Clippings	6.37	8.77	17.1	23.8	38.2	36.9	46.7
Sulphate of ammonia	0	0	0	0	0	0	6.3

In this experiment 30 milligrams nitrogen were added per 100 grams of soil. Such a large amount of nitrogen probably accounts for the poor showing of sulphate of ammonia. The behavior of grass clippings indicates that they have considerable value as a source of nitrogen.

Nitrate Accumulation In Wooster

Source of nitrogen	Per cent nitrogen change to nitrate after 21 days with varying moisture in the soil % water in soil 23	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 was made neutral by adding lime. 20 milligrams nitrogen were added per 100 grams soil.

Several things in these tables may be mentioned as outstanding. FIRST—The acidity of soil 2 (Mass.) has 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 sometime. 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 show that the nitrogen availability in garbage tankage is very low.

THIRD—The effect of too much water in soil in the experiment by Bear 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 overwatering. 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.

Minnesota Short Course

THE University of Minnesota's short course for greenkeepers, which was held February 15-17 was very successful. There were fifty-six registrations, which included one from Wisconsin, five from North Dakota and five from Iowa.

Every subject connected with greenkeeping was covered as far as the short time would permit. Doctor Monteith, of the U. S. G. A. Green Section lectured each day. He described very clearly the grasses for greens and fairways, and told about plant diseases and their control.

There were several speakers on the important subject of "Soils," and the various kinds were well described and analyzed. Mechanical engineers covered the subject of equipment, while other experts discussed trees and landscaping, drainage and irrigation, golf course architecture, and maintenance costs.

It was suggested that next year's course should be continued for a week.