

acted on by chemicals or living organisms in the soil they are converted into forms which are available. Such materials are referred to as being slowly available, and include such fertilizers as bone meal, animal manures, sewage sludge, and waste products. Some of the fertilizers which are classified as unavailable or very slowly available can be made readily available by certain chemical treatments which are used in the fertilizer trade; thus phosphate rock or leather scrap may be treated with sulphuric acid and the fertilizer contained may be made available by the action of the acid. Since fertilizers are applied to furnish plant food, only that which can be classified as available is regarded as of value as an ingredient in fertilizers. The plant food in fertilizers is expressed in terms of nitrogen (N) or ammonia ( $\text{NH}_3$ ), phosphoric acid ( $\text{P}_2\text{O}_5$ ), and potash ( $\text{K}_2\text{O}$ ). For a number of years the nitrogen content of fertilizers has been expressed in terms of both nitrogen and ammonia. Such designation is a duplication, and practically all states have recently agreed to have the nitrogen content of fertilizers expressed in terms of nitrogen only. The fertilizer trade has chosen to express the content of phosphorus and potassium in terms of phosphoric acid and potash, respectively. It is acknowledged that these fertilizer elements do not occur in fertilizers as free nitrogen, phosphoric acid, or potash, but these designations are used in order that there may be a common ground for comparing fertilizer values. In some instances the phosphorus which can be used by plants is designated as bone phosphate instead of phosphoric acid. The bone phosphate content is roughly twice that of the phosphoric acid content, so that when the bone phosphate figure is given one can convert it to approximate terms of phosphoric acid simply by dividing by two. Many of the other terms of the fertilizer trade will be found in the April number of the Bulletin.

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### Some Suggestions on the Selecting of Fertilizers

The question is frequently asked why fertilizers are needed when nature has provided abundantly for plant growth under natural conditions. Plants have decidedly different food requirements, and in the wild state soil which is deficient in one or more fertilizer elements supports only those plants which can get along without the particular fertilizer that is lacking in a particular soil. Since grasses on golf courses are growing under decidedly artificial conditions, it is necessary to use artificial methods for providing the necessary plant food. The plant food in much of the soil used for golf courses has been depleted by poor farming practices which had been used on the land for perhaps many years before it was taken over for golf course purposes. The deficiencies of a run-down farm soil must be replenished. Much plant food collects in the leaves and stems of plants; therefore old leaves and stems left to rot in a natural state add fertilizer to the soil. On golf courses where grass is clipped frequently and either removed immediately or left to be washed down hillsides by heavy rains there is a constant loss of plant food through the removal of these clippings from the soil, and such losses must be compensated by some fertilizing program. Much plant food is also dissolved by rain and washed down through the soil beyond the reach of the grass roots. Certain chemical changes are constantly taking place in the

soil, and together with the decomposition of organic material in the soil these changes account for a loss of certain plant foods which must be replaced to provide for a vigorous growth of grass.

	Nitro- gen (N) Per cent	Phosphoric acid (P <sub>2</sub> O <sub>5</sub> ) Per cent	Potash (K <sub>2</sub> O) Per cent
Activated sludge .....	4-6.5	2.5-3	.....
* Ammo-phos 13-48 .....	10.5	48	.....
* Ammo-phos 20-20 .....	16	20	.....
* Basic slag .....	.....	10-25	.....
Blood, dried .....	8-14	.....	.....
Bone meal, raw ground .....	2-6	14-27	.....
Bone meal, steamed .....	2-4	16-40	.....
Castor pomace .....	4.5-6	1.5-2	.5-3
Commercial 6-12-4 .....	6	12	4
Commercial 12-6-4 .....	12	6	4
Compost of good quality .....	1-2	.5-1	1-1.5
Cottonseed meal .....	3-8	2-3	1.5-2
Fish scrap .....	3-10	5-20	.....
Manure, farm, fresh .....	.5-1	trace-1.5	.5-1
Manure, farm, well rotted .....	.5-1.5	trace-1	.5-1.5
Manure, poultry, pulverized .....	2-6	1-3	1-1.5
Manure, sheep, pulverized .....	2-4	1.5-2.5	1-3
Meat meal .....	10-11.5	1-5	.....
* Muriate of potash .....	.....	.....	48-53
Mushroom soil .....	.5-1.5	trace-1	.5-1.5
* Nitrate of ammonia .....	35	.....	.....
* Nitrate of potash .....	12	.....	44
* Nitrate of soda .....	15	.....	.....
Poultry manure tankage .....	6-7	3	1.5
Soybean meal .....	6.5-7.5	1-2	1.5-2
* Sulphate of ammonia .....	20.5	.....	.....
* Sulphate of potash .....	.....	.....	48
* Superphosphate .....	.....	14-20	.....
* Superphosphate, double .....	.....	40-48	.....
* Superphosphate, treble .....	.....	40-48	.....
Tankage .....	1-11	trace-23.5	trace-1.5
Tobacco dust .....	1-5	.5-1	.5-10
Urea .....	46	.....	.....
* Wood ashes, unleached .....	.....	.....	trace-14

Table giving percentage range of nitrogen, phosphoric acid, and potash contained in various fertilizers. Those marked with an asterisk (\*) are inorganic

In the diagram on the following page a comparison is given of the more common fertilizers on a nitrogen basis. Those familiar with the use of any one fertilizer for golf turf purposes can readily determine from the diagram the approximate amount of some other fertilizer that will be necessary to supply an equal quantity of nitrogen. An application of 2 pounds of sulphate of ammonia, for example, is equivalent to an application of 2½ pounds of nitrate of soda to supply

the same quantity of nitrogen to the same area. Results will however vary slightly when the organic fertilizers are used, since the nitrogen in organic fertilizers is somewhat slower in becoming available to the plant. With the least concentrated organic fertilizers (fresh farm manure, well-rotted farm manure, mushroom soil, and good compost) it is customary to apply two or three times their equivalence with sulphate of ammonia as shown in the diagram. Since however the nitrogen in these least concentrated organic fertilizers is more slowly available than the nitrogen in the more concentrated organic fertilizers or the nitrogen in the inorganic fertilizers, the former are as a rule applied less frequently.

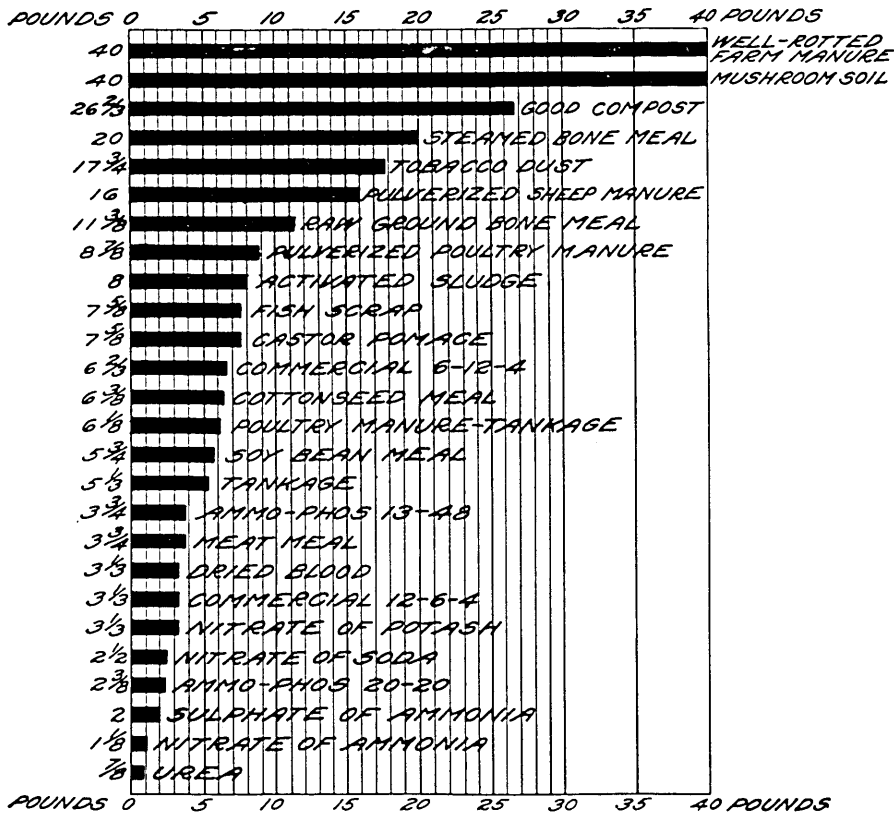


Diagram showing the number of pounds of an average grade of various fertilizers required to supply the same amount of nitrogen

No simple and definite fertilizing program can be recommended for all golf courses, since the use of fertilizer on any golf course is influenced by the demands of the various types of soil, the financial circumstances of the club, the kind of grass composing the turf, and many other conditions that can not be standardized. Lack of any definite fixed program for all purposes, however, does not imply lack of definite information as to general principles involved in fertilizing golf course turf. The absence of understanding of general principles of fertilization is responsible for much waste of funds on golf courses

due to the attempt to follow some programs that have been successful on other courses under wholly different conditions. The kind, the rate, and the time of application of fertilizers must be determined individually for each golf course and for different parts of the same golf course. To be effective, however, this final determination should be based on an understanding of fertilization rather than on the hit-and-miss methods that prevail on the majority of golf courses today. It is of great importance in selecting fertilizers to know what they contain that may be useful to plants and also how soon plants may be able to use this food. When fertilizer is used primarily to improve the growth of grass over a long period, such as is the case in construction work and fairway improvement, it may have a large proportion of plant food in a form that is only slowly available to plants. On the other hand, when putting greens are being fertilized to produce a quick growth to put the turf in prime condition for a tournament, it is necessary to have plant food in a form that is immediately available to the grass. In much of the golf course fertilizing work it is desirable to have both quickly available and slowly available fertilizers in the soil.

The cost of a fertilizer is always an important consideration in selecting fertilizers. In the case of too many golf courses the cost of fertilizer is compared on a ton basis; that is, a fertilizer that costs \$20 a ton is considered cheaper than one that costs \$60 a ton. Such a comparison is, however, often ridiculous, for a fertilizer that costs \$80 a ton may be actually cheaper than one that costs only \$8 a ton. The *value* of a fertilizer should be judged primarily on the amount and character of the plant foods it contains. The present tendency in the fertilizer trade is to produce fertilizers in which the plant foods are extremely concentrated. Fertilizers of this type are more economical than less concentrated fertilizers in the cost of handling, bagging, storing, and distributing. Yet the *cost* of a fertilizer can not be rated entirely on the total amount of plant food it contains. The cost of a unit of nitrogen is much greater than the cost of a unit of phosphoric acid or potash; therefore any fertilizer that contains a higher proportion of nitrogen than phosphoric acid or potash, demands a higher price than mixtures containing a small amount of nitrogen even though the proportion of its total of plant food may be higher. Two different complete fertilizers, for example a 12-6-4 and a 6-12-4, may contain the same amount of total plant food; but due to the difference in the proportion of nitrogen, a ton of 12-6-4 fertilizer is worth more than a ton of 6-12-4 fertilizer. The differences in the values of nitrogen, phosphoric acid, and potash are given in the table near the bottom of page 69 of this number of the Bulletin.

The utilization of wastes and by-products in the manufacture of many fertilizers tends to lessen the price of fertilizers. In recent years there has been a tendency in industry to utilize many of the waste products which formerly were discarded. Much of the waste of the industrial plants is now taken care of by the fertilizer trade, and frequently wastes with much fertilizer value are available at a relatively low cost to clubs in the vicinity of industrial plants where such wastes accumulate. Sometimes this material may be obtained merely for the cost of hauling, and when composted it provides a cheap source of plant foods for turf. Usually these waste products are of only local value because of the limited amounts available and

the cost of hauling. Golf clubs should, however, give consideration to the available local supplies that may contain sufficient plant food to be of value. A number of examples of analyses of such waste products will be given in the April number of the Bulletin.

The cost of some fertilizers is influenced largely by their demand for other purposes. Cottonseed meal and other materials that are used as feed for cattle can be used economically as a fertilizer only in years when the supply is too great to meet the demands for cattle feeding, which results in a reduction in the price that brings them within the range of an economical fertilizer. Such fluctuations in price mean that one year cottonseed meal may be generally recommended as a golf course fertilizer while possibly the next year the price would make it entirely out of the question for such use.

At the present time there are a large number of commercial mixed fertilizers on the market, a few of which will be referred to by name in the April number. Many of these commercial mixed fertilizers are excellent fertilizers for turf and are sold at prices in conformity with the amount of plant food contained. However, in many instances the mixtures are much more suitable for the production of many farm crops than for the best development of golf course turf, or else the price is out of proportion to the value of the fertilizers contained. Because of the great variety of commercial mixed fertilizers it is well to consider every product separately both as to plant food constituents and price. At the present time there is no law to make a manufacturer use the same materials from year to year in a fertilizer of a given formula. He may, according to the price of the materials, change from year to year the kind and amount of materials he uses, provided the total comes up to the minimum analysis which he guarantees. A mixed fertilizer sold under a special name may one year contain large quantities of cottonseed meal, for instance, and the next year, because of the difference in price of cottonseed meal, this same brand of fertilizer may contain none of this material; therefore a greenkeeper who has obtained favorable results from the use of a certain commercial fertilizer one year does not necessarily get the same fertilizer for his course the next year even though he uses the same brand of fertilizer. Commercial mixed fertilizers frequently offer an outlet for fertilizing materials of inferior quality. Care should therefore be exercised in selecting commercial mixed fertilizers. Many of the fertilizer companies gladly give not only the minimum analysis of a fertilizer which is required by law, but also furnish information as to what materials are used in making up the mixture. Such information is of much value, provided the purchaser has a sufficient knowledge of the principles of fertilizers to understand the terms that are used. If a golf club has some one in its employ who has some fundamental information on principles of turf fertilization it may well consider the method of preparing on the golf course its own mixed fertilizers for putting greens and fairways from standard fertilizer ingredients of known quality. This method is simple and requires no particular skill and no unusual amount of information. It usually can be done at a great saving to the club. Detailed information on the preparing of mixed fertilizers on the golf course has been kindly presented by Dr. C. C. Fletcher, of the United States Department of Agriculture, in his article on the subject in the current number of the Bulletin.

Farmers and all others who use fertilizers may take advantage of the provisions made by national and state organizations supported by laws to prevent fraud in the sale of fertilizer materials. The true value of fertilizers can be readily detected by chemical analysis and carefully controlled experimental work, but since very few of those who use fertilizers have the training or facilities for such determinations the national and state governments have provided certain fundamental information and regulations for the fertilizer trade. Many of the reliable fertilizer manufacturers of the country have themselves urged such regulations in order to protect the trade. The Association of Official Agricultural Chemists of North America is an organization composed of analytical chemists connected with the United States Department of Agriculture and with any state, provincial, or national agricultural experiment station or agricultural college, or other institutional body in North America, charged with the official control of fertilizers, soils, cattle feed, dairy products, human foods, medicinal plants, and other materials connected with agricultural industry. This organization includes associate membership of chemists connected with municipal laboratories charged with the control of any of the above-mentioned materials. It was formed to provide uniformity and accuracy in the statement of analyses of the above materials and to afford opportunity for a distribution of information that would be made useful to those who are charged with this work. The organization has already done much to bring about uniformity in the various state and national fertilizer regulations. Golf clubs, like farmers, can profit by the work of this association and the various chemical laboratories handling fertilizer material, provided those who purchase fertilizer for the clubs avail themselves of the information placed at their disposal by these various organizations.

The laws of most states require that a statement of analysis be placed on all fertilizer bags or containers. Such statements are of no value to golf clubs if those who purchase fertilizers for the clubs pay no attention to the statements or plead ignorance of their significance. These statements are simple and are for the protection of all who use fertilizers; and there is really no excuse for anyone with a reasonable amount of intelligence failing to understand the practical significance of the analyses required by law. The significance of these statements is explained in the Bulletin for June, 1928, and further information on this subject will be found in the April, 1931, number. Many state agricultural experiment stations from time to time publish reports of analyses of fertilizers sold within their states. These analyses indicate how closely many of the fertilizer manufacturers conform to the requirements of the fertilizer laws. Every golf club purchasing fertilizer should request of its state agricultural experiment station a copy of its latest report of the analyses of fertilizers sold within the state.

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Impressive bunkers placed about a mashie-shot hole often lend an intensive mental hazard to the hole and make it much more interesting. With a hole so short, a mental hazard is generally the only real hazard possible.