5. Pile the clippings in a tidy heap, well away from the playing area, for removal to compost heap.
6. Carry a knife, and remove individual weeds, as dandelions, and plantains, when first seen.
7. Report weedy conditions, presence of worms or ants, and any general defect that may be observed, when first noticed.
8. Wash off mower with hose on return to barn.

Bunkers

1. Rake sand in traps by drawing from the center to the sides and pull the sand well up on to the turf.
2. Report if you think grass on mounds is too long, as after a soaking rain it might grow so fast as to escape the greenkeeper's notice.

Tractor Mower Operators

1. Do not alter adjustment on gang mowers, but report to greenkeeper or engineer if the units do not appear to be working right.
2. Go over the tractor thoroughly every day to see that all oil and grease cups are free and lubricating properly.
3. Replenish gas, oil and water before putting tractor away at night.
4. Report to greenkeeper if engine is not functioning properly.
5. Maximum speed 4 to 5 M. P. H.

Commercial Fertilizers

By H. L. Westover

The term "fertilizers" is an extremely broad one, having been applied to all substances that are added to the soil for the purpose of improving its capacity to produce plant growth.

The essential elements of plant food are 10 in number, to which may be added three others—sodium, silicon, and chlorin—which seem to be useful under certain conditions. Of the essential elements, four—carbon, hydrogen, oxygen, and nitrogen—are derived directly or indirectly from the air and constitute 90 percent or more of all plant material. The remaining six essential elements—calcium, magnesium, potassium, phosphorus, iron, and sulfur—are derived from the solid portion of the soil. While all these elements are essential, certain ones are more extensively used by crops than others and sooner or later require special attention in the way of increasing the available supply, particularly by applying additional amounts to the soil in some form, while others are used in such small quantities relative to the available supply that they rarely need consideration. The elements of special importance are nitrogen, phosphorus, potassium, and calcium.

Nitrogen

The amounts of nitrogen ordinarily available in nature are small. It is the element of the soil most used by crops and is the most expensive of plant foods of commerce. It is also most elusive, as it is sooner or later lost to plants through change in form. Nitrogen-containing compounds in plants are of special importance in relation to life and growth, since they form an essential part of the protoplasm, which is the living part of the plant cell. It is because of this relation that benefits of nitrogen are so soon displayed in the increased

vigor of growth. Nitrogen is intimately associated with the formation of leaves and stems, resulting in greater vigor and darker green color. Used freely, it has a tendency to retard the development of flowers and to delay maturity, while excessive amounts are apt to render plants less resistant to disease. It is largely because of the beneficial effects of nitrogen to stems and leaves that it is regarded so highly in growing turf grasses, since these are the parts of the plants that the grower of fine turf is most concerned with, rather than the production of flowers or seeds.

The nitrogen used as a fertilizer occurs in both organic and inorganic forms. The organic nitrogen is derived either from animal life, such as fish scrap, tankage, meat meal, and similar products, or from plant life, as cottonseed meal, soybean meal, and such. The inorganic nitrogen occurs as mineral deposits, such as nitrate of soda, or else is manufactured from the air, like urea, Ammo-Phos, and others.

Animal Nitrogenous Materials

The animal nitrogenous fertilizers come largely from the meat-packing industries. In the United States much of the nitrogen used in commercial fertilizers is from this source. Other materials in this class include guanos, which consist largely of the excrements of birds, mixed with the bodies of dead birds, fragments of fish, and similar materials, and the by-products from fish-canning factories and fish-salting plants.

Tankage.—Tankage is composed largely of dried animal waste from large abattoirs. In preparing the material, consisting of a mixture of horn, hair, hoofs, meat, and other animal parts, it is first cooked under pressure in tanks to remove the fat, after which it is dried and ground. Tankage varies greatly in composition but generally carries from 4 to 9 percent nitrogen and 3 to 12 percent phosphoric acid. As a fertilizer for turf grasses it is fairly satisfactory, though not as easily handled as bone meal. Being rather slow-acting, it is best suited for working into the soil just before the seed is sown, though good results follow its use as a topdressing. Because of the variability in composition, tankage should be purchased only on guaranteed nitrogen content.

Dried blood.—Dried blood used in fertilizers is prepared by evaporating, drying, and grinding. The color varies from red to black, according to the method employed in drying. The red blood contains about 13 to 15 percent nitrogen, and the black blood from 6 to 12 percent. The red blood is more uniform in composition, due to the fact that the black blood often contains more refuse. As a top-dressing for putting greens, dried blood has not given very consistent results. This may be partly due to the fact that the availability of its nitrogen is somewhat uncertain, depending very largely on the character of the soil to which it is applied. Its most commendable feature is that it may be used with safety on the finest turf.

Fish fertilizers.—Fish fertilizers, including dried fish, fish scraps, and other such materials, sometimes called fish guano, consist of inedible fish and by-products from fish-oil works, fish-canning factories, fish-salting plants, and other fish industries. Fish fertilizers vary greatly in composition, but usually contain about 8 percent nitrogen. While chiefly valuable for the nitrogen, they also contain considerable phosphoric acid. Fish fertilizers decay readily and soon become

available. They are used on fine turf grasses with beneficial results, but the odor is somewhat objectionable.

Guano.—The use of guano for agricultural purposes is an ancient practice. It was commonly supposed to consist of excrements of sea fowls, but other common constituents are fish bones and bodies of birds and remains of large marine animals. Most of the guano that comes into the market contains 5 to 8 percent nitrogen and about 9 percent phosphoric acid. As the supply is limited, guano is seldom used on golf courses, though applications to any of the grasses are ordinarily quite beneficial.

Miscellaneous materials.—Other nitrogenous animal materials sometimes used in fertilizers are horn and hoof meal, waste leather meal, feathers, and wool and hair waste. The nitrogen in some of these materials is low in percentage and very slowly available in all. They are of little value for use in connection with turf grasses.

Vegetable Nitrogenous Materials

The materials in this class consist of the seed residues in oil factories and are limited in amount. They include cottonseed meal, soybean meal, castor-bean pomace, and linseed meal.

Cottonseed meal.—Cottonseed meal is manufactured from the decorticated seed from which the oil has been expressed. A good quality of meal contains 6 percent nitrogen, 3 percent phosphoric acid, and 2 percent potash. Highly satisfactory results have been obtained in many cases from the use of cottonseed meal as a topdressing for turf grasses. The experiments at the Arlington Farm turf garden, near Washington, indicate that it is preferable to bone meal for this purpose, as it has increased the vigor of the grass and has shown less of a tendency to encourage clover and undesirable weeds. A suitable application is 12 to 15 pounds per 1,000 square feet applied at least three times during the growing season. While the nitrogen is not quite as readily available as that contained in sulfate of ammonia, the results are somewhat more lasting.

Soybean meal.—In recent years soybeans have become a very important crop in the United States. In certain sections, manufacturing plants have been established for the purpose of extracting oil from the seed. The meal that is left after the oil is extracted has given excellent results as a fertilizer for turf grasses, being comparable to cottonseed meal. Soybean meal ordinarily contains a little more nitrogen and a little less phosphoric acid than cottonseed meal, and the two seem to be about equal in value for turf grasses. The value of soybean meal as a feed for livestock has a tendency to keep its price above its relative value for fertilizer.

Castor-bean pomace.—Castor-bean pomace is the by-product of castor-oil factories. Its chief use is for fertilizer purposes. It has no value as a stock feed. It is not quite as rich in plant-food constituents as cottonseed meal, usually containing about 5½ percent nitrogen, 2 percent phosphoric acid, and 1 percent potash.

Linseed meal.—Linseed meal is the residue left after extracting the oil from flax seed. Its extensive use as a cattle feed makes it too high-priced for common use as a source of nitrogen in commercial fertilizers. In composition it is quite similar to castor-bean pomace.

Inorganic or Mineral Compounds of Nitrogen

The materials in this class until recently came largely from natural deposits, but more recently large quantities have been derived

from by-products of certain manufacturing operations, or else are manufactured products. Included in this group are sulfate of ammonia, nitrate of soda, ammonium nitrate, and potassium nitrate. At the present time considerable quantities of inorganic nitrogen are, in part at least, direct products of manufacture from the air, such as cyanamid, calcium nitrate, urea, and ammonium phosphate.

Sulfate of ammonia.—Sulfate of ammonia is obtained chiefly as a by-product in the manufacture of illuminating gas, and is extensively used as a fertilizer. It usually contains about 20 percent nitrogen. Its chief advantages are, that it is concentrated; is a definite product; and is quick-acting. It should not be mixed with alkaline substances, like wood ashes or basic slag, otherwise nitrogen is liberated in the form of ammonia. It leaches less quickly than nitrate of soda.

Sulfate of ammonia is one of the most satisfactory fertilizers for topdressing turf grasses, particularly the bents, fescues, and Bermuda grass. Its advantages over most other fertilizers are that it furnishes nitrogen, so essential to the proper growth of grasses, in a readily available form, and at the same time has a tendency to make the soil progressively more acid, thus controlling the growth of chickweed, crab-grass, clover, and other weeds. As sulfate of ammonia is not lasting in its effects, frequent light applications are advisable. At the Arlington Farm turf garden monthly applications of 3 pounds to 1,000 square feet have given excellent results. To avoid injury from burning, sulfate of ammonia should be applied mixed with compost, or in solution, and watered in. In establishing new greens it is better to defer application until the grass is well started, otherwise much of the fertilizing value will be lost by leaching before the grass is able to utilize it. Furthermore, germinating grass seeds, and grass seedlings, are less able to resist the burning effect than established grass, and may be killed. No bad results have followed long continued use of sulfate of ammonia on turf grasses where they are frequently topdressed with compost.

Nitrate of soda.—Nitrate of soda is a natural deposit in parts of South America, and ordinarily contains about 16 percent nitrogen. It is the most active of all nitrogenous fertilizers. It is extremely soluble and should be used sparingly, as it can not be retained in the soil. Grass responds to applications of nitrate of soda, as is shown by the rank growth of dark green foliage, but excessive amounts may produce injurious results. Unlike sulfate of ammonia, it tends to create an alkaline condition in the soil, thereby encouraging the growth of crab-grass and other weeds that prefer an alkaline soil. On account of its pronounced caustic effect it must be used with extreme care on putting greens. The rate of application recommended is the same as for sulfate of ammonia.

Ammonium nitrate.—Ammonium nitrate is now being manufactured in Norway. It is highly concentrated and leaves no injurious residue in the soil. When pure it contains about 35 percent nitrogen. At present the price is too high to warrant its use as a fertilizer and it is seldom used for this purpose.

Potassium nitrate.—Potassium nitrate is found in a natural state in Egypt, India and South Africa. The impure salts contain 14 percent nitrogen and 44 percent potash. Potassium nitrate is so much in demand for manufacturing purposes that little of it is used as a fertilizer.

Cyanamid.—Cyanamid is one of the nitrogeneous fertilizers made by using the nitrogen of the air. It contains about 15 percent nitrogen, which is fairly quick in its action, being about equal to the nitrogen in sulfate of ammonia. Several tests indicate that the nitrogen of cyanamid is not as valuable pound for pound as the nitrogen of nitrate of soda or sulfate of ammonia. Cyanamid injures young plants unless distributed in the soil some time before planting. Unlike sulfate of ammonia, it tends to create an alkaline condition in the soil, thus encouraging certain weeds.

Calcium nitrate.—Calcium nitrate is another air product containing about 15 percent nitrogen. Its chief drawback is its tendency to take up moisture in a moist climate. It also has a tendency to make the soil alkaline.

Urea.—Urea, or Floranid, is one of the nitrogenous fertilizers made in Germany from the air. It is the most concentrated of all nitrogenous fertilizers, containing 46 percent nitrogen in a soluble form. Unlike most fertilizers, urea affects the acidity of the soil only temporarily. At the Arlington Farm turf garden, while giving good results, it has not proved equal to sulfate of ammonia or Ammo-Phos.

Ammonium phosphate.—Ammonium phosphate is generally classed with the fertilizers manufactured from the air, though only partially an air product. The ordinary brand of commerce, sold under the name Ammo-Phos, comes in two grades, one with 17 percent nitrogen or 20 percent ammonia and 20 percent phosphoric acid, and the other with about 11 percent nitrogen or 14 percent ammonia and 48 percent phosphoric acid. This is one of the quick-acting fertilizers, and like other quick-acting materials results are not lasting. In tests at the Arlington Farm turf garden ammonium phosphate and sulfate of ammonia have given comparable results. Both increase the vigor of the grass and at the same time tend to check the growth of weeds that prefer an alkaline soil. To avoid burning the grass, ammonium phosphate should be applied mixed with compost, or in solution, and watered in. Monthly applications of 3 pounds per 1,000 square feet have given good results.

PHOSPHORUS

Phosphorous compounds are found everywhere in the soil and are of great value in their relation to plants. Phosphorus occurs in the seeds in larger amounts than in any other part of the plant, and for this reason plants like the small grains, in which seed production is the important feature, require more than the grasses, where vigorous vegetative growth is the end sought. Most soils have sufficient phosphorus for growing turf grasses, especially where manure has been used in preparing the seed bed, while compost used as a topdressing on putting greens ordinarily maintains an ample supply. When used too freely, phosphorus encourages the growth of clover and other weeds that are objectionable on golf greens. The leading commercial sources of phosphorus as a plant food include bone meal, superphosphates, basic slag, and raw rock.

Bone meal.—Two kinds of bone meal are found on the market. They are known as "raw bone" and "steamed bone." The former receives no treatment before grinding, while the latter is first subjected to superheated steam until the fat and scraps of meat have been removed. The "steamed bone" is the form most commonly used

and is said to be somewhat more readily available than the "raw bone." Whether raw or steamed, the value of bone meal depends to a large extent upon the degree of fineness. The finer the particles are the more quickly they become available. A good grade of bone meal contains from 3 to 5 percent nitrogen and 18 to 20 percent phosphoric acid.

Where soils are low in fertility and where well-rotted manure is not available, bone meal worked into the soil before the seed is sown will ordinarily be found of material benefit in establishing turf grasses. It may also be used to advantage for topdressing fairways, where a uniform turf is not particularly important. When used as a topdressing on putting greens it increases the vigor of the grass but at the same time tends to encourage clover and other weeds to a greater extent than does cottonseed meal. It is the common practice to apply bone meal in the spring, but there is some evidence to indicate that better results follow winter applications. Fifteen to 20 pounds per 1,000 square feet is the rate of application usually recommended for topdressing. When incorporated with the soil, somewhat larger amounts may be used to advantage. Bone meal is easily applied, and no burning or other injurious effects have ever been observed from its use.

Superphosphates.—The superphosphates include acid phosphate, dissolved bone, and bone black. Of these, the acid phosphate is by far the most important commercially. It is made by treating phosphate rock, which occurs in nature, with sulfuric acid, thereby changing the phosphorus into a form that is available to the plant. While somewhat variable in composition, the grade ordinarily sold on the market contains 16 percent phosphoric acid. The concentrated or double superphosphates, which are made by further treatment of 16 percent acid phosphate, contain as high as 44 percent phosphoric acid. If well made, the superphosphates are free from acid, and while readily available to the plant are not easily washed from the soil. Superphosphates should be used rather sparingly on golf courses, particularly on bent-grass greens, as they tend to encourage the growth of clover.

Basic slag.—Basic slag is a waste product from the manufacture of steel. It is variable in composition but usually contains from 16 to 19 percent phosphoric acid. The availability is dependent to a large extent upon the fineness of division. Repeated applications of basic slag reduce the soil acidity and thereby have a tendency to bring in clover and other plants requiring an alkaline condition. For this reason it is not recommended for use on putting greens where a pure stand of grass is desired.

Raw rock phosphate, or floats.—Raw rock phosphate is made by grinding phosphate rocks, which occur in parts of South Carolina, Florida, Tennessee, Idaho, Wyoming, and Montana. The raw rock phosphates are insoluble in water and are incapable of furnishing plant food directly, but must decay first; hence their usefulness depends upon decay or a change to such a form as is available to plants. The rate of decay depends to a considerable extent on the fineness of division. As the raw rock phosphate is slow in decaying, its effects are not apparent for some considerable time after applying. It is of little value in growing fine turf grasses.

POTASSIUM

Potassium plays a very peculiar role in plant growth. It is most abundant in young and growing parts, where activity is greatest, and least abundant in parts that have ceased to grow. Potassium compounds are absolutely essential in order that the plant may produce starch, sugar, cellulose, and other carbohydrates. It is also believed to aid in transference of starch from one part of the plant to another. It is most abundant in stems and leaves, and, where deficient, stems are apt to be weak and brittle. Most soils carry enough potassium for turf grasses. Any deficiency that exists is usually remedied if manure is used in preparing land for sowing, or by subsequent topdressings with compost. Heavy applications of potassium on fairways or putting greens are undesirable, as they promote the growth of clover.

Wood ashes.—Until the discovery of mines of crude potash salts the chief source of potash other than that contained in stable manure was wood ashes, which may contain from 2½ to 12 percent potash, though as offered on the market the amount usually varies from 3 to 8 percent. Softwood ashes contain less potash than hardwood ashes, while coal ashes and unprotected ashes from sawmills where softwood is burned are of little value. Although generally regarded as a potash fertilizer, ashes also carry 30 to 35 percent calcium oxid and a small amount of phosphoric acid. Wood ashes correct acidity, improve the mechanical condition of the soil, and aid nitrification, but since they encourage the growth of clover they are not desirable for use on putting greens.

Muriate of potash.—Muriate of potash (potassium chlorid) is a product prepared from the crude materials of the German potash mines, purified by special treatment. It varies in composition, but most of that offered on the market is guaranteed to contain the equivalent of 50 percent actual potash (K_2O). Muriate of potash is the most generally used of the potash salts.

Sulfate of potash.—Sulfate of potash (potassium sulfate) is another of the manufactured products of the German potash mines. It comes on the market in two grades, the more common form containing 48 percent potash (K_2O).

Potassium carbonate.—Potassium carbonate is used to some extent as a fertilizer and to some extent on compost heaps. It contains 65 percent potash (K_2O) and is recommended where chlorids and sulfates are to be avoided, as for instance in the growing of tobacco.

Potassium nitrate.—Potassium nitrate is one of the oldest and best-known sources of potash. In addition to the 12 to 14 percent nitrogen, it has 44½ to 45½ percent potash. It is especially valuable where it is desired to avoid sulfates or chlorids, but the supply is limited and the price high.

MIXED FERTILIZERS

Mixed fertilizers, as the name implies, are preparations made by mixing plant-food materials of different kinds. The materials used include manufactured products, substances in or from natural deposits, and by-products from various industries. Their agricultural value depends chiefly upon the forms and amounts of the three plant-food elements, nitrogen, phosphorus, and potassium. Mixed fertilizers are either complete, carrying all three elements, or incomplete, carrying only one or two elements.

In nearly all states manufacturers are required by law to indicate on each package of mixed fertilizer the percentage of nitrogen, phosphoric acid, and potash contained. They should also be, and in some states are, required to show the kind of material used in the mixture. The analysis of a fertilizer may show a high percentage of nitrogen, for instance, and yet it may have a low agricultural value due to the fact that the nitrogen is in a form that is very slowly available to the plant. Leather waste, hoofs, horns, and hair carry a high percentage of nitrogen, yet unless treated so as to make them soluble they are of little value as a fertilizer, since they decay so slowly. Until a fertilizer goes into solution it can not benefit a growing plant.

Many of the large fertilizer companies put out special fertilizers for special purposes. These are sometimes put out under a brand-name, though many of the larger companies have discarded the practice and designate their fertilizers by their composition, as 3-8-3 or 3-8-6 goods. These figures refer to the parts per 100 of nitrogen, phosphoric acid, and potash, in the order named. In some localities the order of nitrogen and phosphoric acid is reversed. The purchaser of mixed fertilizer always gets considerable filler and pays considerably more for the various ingredients than if purchased separately.

While mixed fertilizers are used to advantage under certain conditions, particularly in preparing land for grass, it is usually better to avoid them in growing turf. Fertilizers containing phosphorus and potash tend to encourage clover and various weeds, and most soils contain sufficient of these elements for turf grasses. Any deficiency that may exist is remedied where manure is incorporated with the soil in preparing it for a putting green. Topdressings of compost furnish additional phosphorus and potash, nitrogen being the only plant food required in larger amounts. In seeding fairways where the soil is poor and manure not available, mixed fertilizers are sometimes used to advantage. Even here, however, the percentage of nitrogen should be high in proportion to phosphorus and potash, and in a form that will be available within a reasonable length of time.

LIME

The basic substance in the various lime materials is calcium. In plants calcium strengthens the cell walls, encourages the growth of root hairs, and appears to be associated with the transference of starch within the plant, it is found mainly in the stems and leaves.

Lime is one of the indirect fertilizers—that is, it favorably influences crop growth through the effect on the soil rather than through the addition of plant food. It is contained in most soils in sufficient quantities for plant growth, though certain plants are benefited by applications of lime.

The calcium compounds available for agricultural use as indirect fertilizers are calcium oxid, calcium hydroxid, calcium carbonate, and calcium sulfate.

The calcium oxid, otherwise known as burned lime, caustic lime, quick lime, unslaked lime, and lump lime, is prepared by heating at a sufficiently high temperature any form of carbonate of lime, as limestone, oyster shells, or shell marl. When pure it contains 71.4 percent calcium. Burned lime, when applied to the soil, changes very quickly to hydrated lime, and sooner or later to carbonate of lime, in which form it does most of its work.

When calcium oxid comes in contact with water it undergoes a change known as slaking, resulting in the production of a chemical compound known as calcium hydroxid, which in everyday parlance is slaked lime or hydrated lime. This represents burned lime diluted by combination with about one-third its weight of water.

Ground lime and ground oyster shells are just what the names imply and are the carbonate form of calcium, which is more dilute than either the burned lime or hydrated lime.

Calcium sulfate, otherwise known as gypsum or land plaster, is a compound of calcium and sulfuric acid. It is particularly beneficial to leguminous crops. Unlike the calcium compounds previously discussed, its continued use has a tendency to increase the acidity of the soil.

To furnish the same amount of calcium as is contained in 100 pounds of burned lime requires 130 pounds of hydrated lime, 180 pounds of ground limestone, and 310 pounds of gypsum.

Lime is of benefit in various ways. It makes available insoluble forms of plant food, especially in compounds containing potassium and phosphorus; it neutralizes the effects of compounds that interfere with plant growth, such as acid and toxins; it favors the decomposition of organic matter; it makes conditions more favorable to the action of certain bacteria; it improves the physical character of sticky clay soils; and it has a tendency to check certain diseases.

Injurious results may follow the injudicious use of lime. Used too freely, burned lime results in the loss of organic matter through too rapid decomposition; it results in the loss of nitrates by furnishing them faster than the plants can use them; it checks nitrifying organisms; and it encourages certain diseases. Certain plants, particularly the legumes, require an excess of lime in the soil for their best development, while others do best in an acid soil. The latter seems to be the case with most turf grasses, particularly the bents and fescues. Bluegrass is believed to be a lime-lover, mainly because of the wonderful bluegrass characteristics of the calcareous soils. But calcareous soils are notoriously rich, and it is equally probable that the fine bluegrass turf is due to the high quality of the soil and not to the lime specifically. At any rate, bluegrass of high quality can be found on soils poor in lime, especially if they are high in plant food. When lime is applied to the soil it creates a condition favorable to the growth of clovers and weeds, particularly crab-grass, and for this and other reasons is not recommended in growing turf grasses.

The golf course village.—It is often the case that in establishing a golf course both the necessity and the desirability arise of planning in some measure for the growth of a village in its neighborhood. If such a village is thoughtfully planned during its inception or early stages of growth it goes a long way toward materially enhancing the attractiveness of the golf course. The subject of rural village planning has been studied in detail by Department of Agriculture experts, and the results of their studies have been published in a 45-page bulletin, extensively illustrated, which is available without charge to interested persons upon application to the United States Department of Agriculture. This is Farmers' Bulletin No. 1441, "Rural Planning; the Village." It discusses, among other matters, the problems of streets, parks, river-bank improvements, railway and trolley approaches, waterfronts, sanitation, roads, and public buildings.