Phosphorus as a Fertilizer on the Dairy Farm

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Phosphorus must always play an important part in any system of permanent agriculture. It is absolutely necessary for the growth and development of all plant and animal life. It is found in every cell and without it none of the cell activities could go on. Whether the system of farming is strictly grain or strictly live-stock, phosphorus is largely used in the formation of the seed. About three-fourths of the phosphorus required for the ordinary farm crops, corn, oats, wheat, goes to form the grain, and the grain is the part of the crop sold from the farm. The grain of a hundred bushel crop of corn requires 17 pounds of phosphorus while the stalks require only 6 pounds. The grain of a hundred bushel crop of oats requires 11 pounds of phosphorus, while the straw requires only 5 pounds. The grain of a fifty bushel crop of wheat requires 12 pounds of phosphorus, while the straw requires only 4 pounds.

When the products of the farm are fed to live-stock a large part of the phosphorus, probably one-fourth, is retained by the animal body to build up the bones and to assist the organs is performing their life activities. Bones are composed almost wholly of calcium phosphate, a compound of calcium, oxygen, and phosphorus. Of the three-fourths of the phosphorus that passes thru the animal in the form of manure, probably not more than two-thirds of the the phosphorus that through the animal in form of
manure, probably not more than two-thirds of it ever gets back to the farm, because of improper methods of handling the manure. While the loss is probably not so great in dairy farming where only dairy products are sold as where meat products are sold, still the loss is considerable.

When a thousand-pound fat steer is sold from the farm 7 pounds of phosphorus go with it. In 1000 pounds of fat hogs, 3 pounds of phosphorus are sold. In 550 pounds only two-tenths of a pound of phosphorus are sold. If only butter was sold from the farm and and all of the manure could be saved and returned to the land without loss, the depletion of the soil phosphorus would go on very slowly. But, of course, it is not possible to do this, either to sell only butter, or to save all of the manure. So we see, whether the system is grain farming, where the grain is fed for the production of meat or milk, the result is the same.

The other elements, nitrogen and potassium also disappear from the farm under either the grain or livestock system of farming, but not to the same extent. Only about two-thirds of the nitrogen and one-fourth of the potassium is in the grain, the rest being in the stalks and straws. When the grain is fed about one-fourth of the nitrogen is retained by the animal but practically none of potassium. The nitrogen, to maintain the supply in the soil, may be secured from the air without cost by growing legume crops, while the supply of potassium will practically be maintained, if good use is made of all stalks and straws, and the manure carefully saved.

On most soils of Illinois and southern Wisconsin the problem of the farmer is to maintain the supply of nitrogen and phosphorus. In providing for the nitrogen supply of humus will also be provided for. The potassium content of the normal soils of this region is so great that there is no likelihood of it ever being reduced to the point where it will be necessary to use commercial potassium. On peaty and alkali soils potassium can be used with profit.
In grain farming the nitrogen must be maintained by growing legume crops, such as clover, the stock peas, the soybeans, the vetches, and the alfalfas, and plowing them under, and by returning the crop residues, as corn stalks, oats, and wheat straw, and possibly by growing legume catch crops.

In live-stock farming the manures must be depended upon largely to provide the nitrogen and humus. No matter, though, which system is followed, it is far from an easy matter to maintain the nitrogen and humus in the soil and farmers should not be led to believe that a mere rotation of crops will do it; or that even the growing of clover will do it if the clover is not left on the land. Where only the produce of the farm is depended upon it is easier for the grain farmer to maintain the supply of nitrogen and humus than it is for the live-stock farmer.

From the standpoint of maintaining the phosphorus content of the soil, the live-stock farmer has the advantage, and of the various classes of live-stock farmers, the dairyman has the greatest advantage, because less of the phosphorus is sold from the farm in dairy products than in meat and bones.

Many dairymen, in fact most of them, buy a large part of their feed, especially the concentrates as bran and oil meal. Where this is done on an extensive enough scale and the manure carefully saved and applied to the land, all of the elements of plant food may be provided for in sufficient quantities for large crops. It should, however, be the ambition of every dairyman to grow on his own farm all of the feed for his cows. This can be done, too, if proper methods are adopted so that clover and alfalfa can be grown successfully. It is now known that ton for ton, well cured alfalfa hay is about as valuable as bran for feeding dairy cattle. It is also known now that alfalfa can be grown on any land in Illinois or Wisconsin that will grow corn successfully. It will usually be necessary to give the land special attention to get the alfalfa start-
ed. It should be well drained and well manured, and on any but limestone soil, liberal amounts of limestone should be applied.

By growing clover and alfalfa to furnish the protein of the feed and by using large amounts of straw for bedding to absorb all of the liquid manure, sufficient nitrogen and humus should be provided for in the manure produced on the farm to grow large crops of corn and oats. The clover and alfalfa of course get their nitrogen from the air. Enough phosphorus then can be purchased at a nominal expense to maintain the soil in a permanently productive capacity.

Phosphorus might be applied in the form of manure, but where only produce grown on the farm is used, not enough can be made. It might be applied in bone meal but this form is comparatively expensive. It might be applied in acid phosphate, but this form is also expensive and not very satisfactory because of the free acid which it contains. The only other form that could be used is the natural raw rock phosphate. This is very much the cheapest form, and dairy farming provides ideal conditions for its proper use. Raw rock phosphate, as its name implies, is a raw product. It is simply a raw rock ground into a very fine powder. In its natural state it is almost wholly insoluble in water. The fertilizer manufacturers treat it with strong sulfuric acid to render it soluble in the making of acid phosphate. But we have seen that this is objectionable because of the free acid which it contains as well as because of its expensiveness.

The phosphorus in the soil is in the form of rock phosphate, and is insoluble except as the farmer makes it soluble by using large amounts of decaying organic matter, as farm manures and green manures. The phosphorus in a soil deficient in humus is in just as inert a condition as the raw rock phosphate fresh from the mines of Tennessee. If the phosphorus in the soil can be made available by decaying organic matter, raw rock phosphate can also be
made available by the same means. And manure is the very best kind of organic matter to use as it readily decays in the soil. Raw rock phosphate is not only cheap, but its phosphorus content is high. It is as rich in phosphorus as pure steamed bone meal, twice as rich as acid phosphate, costs only about a third as much as steamed bone meal, and only a fourth as much as acid phosphate.

Phosphorus has at least three distinct actions on the crops. It has a indirect action on the grain crops in that it increases the yield of clover thus providing more humus and nitrogen in increased amounts of manure. And it exerts a beneficial action in making it possible to grow more thrifty and vigorous plants to resist the attacks of insect enemies and fungous diseases. It is a well known fact that insects attack the weakest plants.

Much work has been done with raw rock phosphate used in connection with decaying organic matter. Probably the oldest and best known experiments have been conducted by the Ohio Experiment Station, using manure as the form of decaying organic matter. An experiment was begun in 1897 for the purpose of comparing manure that had been exposed to the weather in an open barnyard during the winter with that taken directly from the stable to the field, and of studying the effect of treating the manure with reinforcing materials. Four parcels of manure were used in the experiments, two from the open yard, and two from the stables. With one parcel of each kind of manure 40 pounds of raw rock phosphate were mixed with each ton of manure, while the other parcels remained untreated. Eight tons of each kind of each kind of manure were hauled out and spread on a clover sod that was to be planted to corn. This was in a three-year crop rotation of corn, wheat, and clover. The experiment was carried on on three fields so all three crops were represented every year. As an average of 11 corn crops, 10 wheat crops and 7 hay crops the increases per acre were as follows:
Yard manure, untreated, gave an increase of 16.8 bu. of corn, 8.5 bu. wheat, .32 tons hay.

Stall manure, untreated, gave an increase of 23.1 bu corn, 9.9 bu. wheat, .60 tons hay.

Yard manure and rock phosphate gave an increase of 23.1 bu. corn, 13.1 bu. wheat, .75 tons hay.

Stall manure and rock phosphate gave an increase of 29.4 bu. corn, 15.2 bu. wheat, 1.16 tons hay.

Reducing this to money values, counting corn at 35 cents per bushel, wheat at 70 cents per bushel, and hay at $6.00 per ton the increases amount to the following sums:

- Yard manure, untreated: $13.74
- Stall manure, untreated: 18.61
- Yard manure and rock phosphate: 21.76
- Stall manure and rock phosphate: 27.89

Comparing the yard and stall manure it is seen that each ton of yard manure gave a value in increased crop yields of $1.72 while the stall manure gave a value of $2.33. A ton of yard manure treated with 40 pounds of raw rock phosphate gave a return of $2.72, while a ton of stall manure treated 40 pounds of raw rock phosphate gave an increase of $3.49.

The 40 pounds of raw rock phosphate was figured at 17½ cents. Then by using 17½ cents worth of raw rock phosphate in connection with a ton of yard manure the value was increased $1.00, or for every dollar invested in raw rock phosphate and used in this way, $5.71 were returned in increased crop yields, a clear profit of $4.71. Where the rock phosphate was used with stall manure each dollar returned an increase of $6.63, a clear profit of $5.63.

Long continued experiments with the use of raw rock phosphate have been reported by the Maryland Experiment Station, the Pennsylvania Experiment Station, the Massachusetts, and a number of others. The results have uniformly been satisfactory where the supply of decaying organic matter in the soil has been maintained. Illinois has done an immense amount of work in the use of phosphorus. On the University farm at Urbana the use of pure steamed bone meal
increased the yield of corn as an average of the past six years from 68 bushels to 88 bushels per acre, a gain of 20 bushels per acre. In 1909 the increase due to clover, lime and phosphorus over clover and lime was 44 bushels per acre. The increase, due to manure, lime and phosphorus over manure and lime was 30 bushels per acre.

On one of the soil experiment fields in southern Illinois phosphorus increased the yield of wheat from 19 bushels per acre to 27 bushels per acre as the average of 6 years. On the Antioch soil experiment field in Lake County only a few miles from the Wisconsin line, phosphorus added to nitrogen gave an increase over nitrogen alone valued at $4.51 per acre as an average of 6 years work. In the use of raw rock phosphate in connection with decaying organic matter we also have a large amount of information. As an average of 32 distinct and entirely separate tests conducted on eight different fields in six different counties, the average yield of corn in 1908 was increased 9 bushels per acre where raw rock phosphate had been used during the previous four or five years.

Many practical farmers of Illinois have used raw rock phosphate under the direction from the Illinois Experiment Station with excellent results. Among the many I can only mention the most prominent, Mr. Frank I. Mann of Gilman, a director of the State Farmers' Institute and a member of the Advisory Committee of the State Farmers' Institute on soil investigations by the Experiment Station. Mr. Mann has a farm of 50'/ acres of $200 land in the heart of the corn belt on which he has been using raw rock phosphate for the past five or six years in a four year rotation of corn two years, oats, and clover. The rock phosphate is always applied to the clover sod, 1000 pounds per acre, and plowed down for corn. In 1906 an 80 acre field of oats yielded 80 bushels on treated land and 60 bushels on land not treated. The same year a 60 acre field of corn yielded 55 bushels on treated land and 40 bushels on land not treated. In 1907 an 80 acre field of corn yielded 62 bushels on treated land and
45 bushels on land not treated. The same year on an 80 acre field of oats rock phosphate increased the yield from 25 bushels per acre to 40 bushels per acre.

In 1908 rock phosphate increased the yield of wheat from 26 bushels per acre to 41 bushels per acre and oats from 25 bushels per acre to 50 bushels per acre. In 1909 a 40 acre field of 20 year old pasture sod yielded 59 bushels of corn per acre on untreated land and 81 bushels on treated land. Also in 1909 on an 80 acre clover sod that had been in continuous cultivation under the four year rotation for thirty years, without manure or pasture yielded on the untreated land 65 bushels of corn and on treated land 81 bushels per acre.

In 1908, an 80 acre field of clover yielded 2½ tons of hay in the first cutting on the treated land and only 1½ tons on the untreated land.

Phosphorus not only produces larger yields of grain, but the grain is of better quality. It hastens maturity and fills out the grain better. Grain grown on soil well supplied with phosphorus is always plumper and heavier than grain grown on soil deficient in phosphorus. In 1906 oats grown on land to which phosphorus had been applied weighed 35 pounds per bushel while the oats grown on untreated land weighed only 26 pounds per bushel. The same is true of corn and wheat.

Raw rock phosphate, finely ground and carrying 12 to 12½ per cent of the element phosphorus, can be purchased from a number of firms in Tennessee for $3.00 to $4.50 per ton and the freight rate to northern Illinois or southern Wisconsin should not be more than $3.50 to $4.00 per ton. This means that enough phosphorus can be bought in raw rock phosphate for $8.00 or $9.00 to produce a thousand bushels of corn. This is at a cost of less than one cent per bushel.

The yielding possibilities of the soil are almost unlimited where the necessary plant food is provided. One acre of land in North Carolina in 1909 produced 226½ bushels of
corn. The grower, however, applied commercial fertilizers to the value of $58.80 in addition to 45 loads of manure valued at $56.25. While we do not expect to grow 200 bushels of corn per acre in Illinois or Wisconsin, still we should not be satisfied with what we are producing. If farmers would plan systems whereby the nitrogen and humus content of the soil could be increased and then use liberal amounts of phosphorus, the soils of Wisconsin could be made more productive than they ever were in their virgin state.

Dairymen, above all other people are ideally situated to do this. They need to grow largely of legumes to balance their grain feed. They can save more of the manure to provide nitrogen and decaying organic matter to liberate the phosphorus from the raw rock phosphate. If they would only do this, the dairy section of southern Wisconsin would indeed become a garden spot.