The Potash Problem in Kentucky Agriculture

By George Roberts

Circular 432

UNIVERSITY OF KENTUCKY
College of Agriculture and Home Economics
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To Meet the Potash Problem on Kentucky Farms . . .

1. Use potash fertilizers on soils naturally deficient in potash. If in doubt, make small plot tests on the fields, and have chemical soil tests made.

2. Grow enough legumes in crop rotations to fix large amounts of nitrogen. Conserve and return to the soil as much as possible of the crop residues and manure. Drag pastures at least twice a year to scatter manure dropped on them. Make field tests and chemical tests for need of additional potash.

3. For alfalfa in rotation on soils that do not supply enough potash for it, apply fertilizer potash for the alfalfa. Don't use manure on the alfalfa, for it retards nitrogen fixation. Use manure on the nonlegume crops in the rotation, and as far ahead of the legumes as is practical.

4. For high-priced crops like tobacco, if enough manure is not available, fertilize liberally with fertilizer potash along with other needed fertilizers, and carefully save and protect tobacco stalks for fertilizer. They are best applied about the time spring growth of crops begins.

5. Keep the soil covered with grass or cover crops to prevent losses by leaching and erosion.

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Potassium is one of the mineral elements required in large amount by crops. The approximate content of potash[2] in some of the crops commonly grown in Kentucky is as follows:

	Pounds of Potash
Corn, 50 bushels, including stalks	50
Wheat, 25 bushels, including straw	35
Alfalfa hay, 1 ton	50
Clover hay, 1 ton	40
Lespedeza hay, 1 ton	30
Timothy hay, 1 ton	30
Burley tobacco, 1000 pounds leaf and 600 pounds stalks	55

Even though a soil may contain a large amount of potash, there is at any one time only a small part of it in a form that can be used by plants. It is very evident, therefore, from this fact and the above figures, that unless much of the potash taken up by crops is returned to the land, either in crop residues and manures or in fertilizer potash (or both), there will soon be a potash deficiency which will reduce yields of crops. This is the potash problem in Kentucky farming. It is brought on largely by the fact that such large quantities of crop residues and farm manure are wasted on Kentucky farms, and it is aggravated by the fact that many farmers fail to recognize the great importance of potash in their soil-fertility problems.

Manure and Crop Residues Contain Much Potash

By saving all possible crop residues and animal manure and returning them to the soil, and by using practices which prevent the nutrients in the residues and manure from being wasted by leaching and erosion, farmers can maintain supplies of available potash in their soils that will greatly reduce the need for commercial-fertilizer potash. For best yields on most farms, some fertilizer potash will be needed

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[2] The term "potash" is used in this circular instead of "potassium" because "potash" is the term generally used both in the fertilizer industry and by farmers. Potash content of a soil or fertilizer is equal to 1.2 times the potassium content of it.

for some crops, because even with the most careful saving of crop residues and manure, not all the potash removed from the soil by crops can be returned.

About nine-tenths of the potash in feed eaten by animals is contained in the urine and solid manure. Most of this potash can be returned to the soil if the right methods are used in conserving the manure produced. About two-thirds of the potash excreted by animals is contained in the urine. Most of this is lost unless there is plenty of bedding to absorb the urine. Also, a large part of the potash in the solid excrement is soluble in water and is lost if the manure is exposed to rain before spreading. The wastage of farm manure in Kentucky is estimated at about 16 million dollars a year. Probably not more than 60 percent of the fertilizer value of manure is utilized. Stock should be fed and kept under cover except when they are on pasture, and the manure needs to be kept under cover until it is spread. Pastures need to be dragged at least twice a year to scatter the dunghills and make the manure more effective.

Two-thirds to three-fourths of the potash of grain crops is in the stalks and straw. These should always be returned to the soil, preferably after being used as bedding for animals fed under cover.

Tobacco stalks contain considerable amounts of potash. For each 1000 pounds of burley leaf there are about 600 pounds of stalks—and this amount of stalks contains about 20 pounds of potash. Most of this potash is soluble in water and is soon lost when the stalks are exposed to rain. Loss of potash (and of nitrogen also) through improper care and use of tobacco stalks in Kentucky is enormous.

Cropping Practices in Relation to Potash

Tobacco is a heavy feeder on potash. Unless heavy applications of manure are made, land for tobacco should be liberally fertilized with a fertilizer containing a high percentage of potash as well as of nitrogen and phosphorus.

Hay crops, especially alfalfa, also are heavy feeders on potash. Too many farmers think that a good growth of a legume crop improves the soil even though the crop is harvested for hay and no manure is returned. As a matter of fact, all hay crops deplete the soil of the mineral nutrients unless the manure produced from the hay is systematically returned to the soil.

One ton of alfalfa contains about 50 pounds of potash. Alfalfa that yields 3 tons per acre per year for 5 years takes about 750 pounds of potash from the soil, per acre. No soil can stand such a drain without serious deficiencies appearing, unless the potash is returned in fertilizers or manure. Yet many farmers use a seeding of alfalfa for hay as long as the yields justify cutting; then they put the land in other crops without replenishing the potash. The depletion of potash accounts for many of the poor yields following several years of alfalfa. This is particularly true of tobacco following alfalfa, for tobacco requires a large amount of potash in a short time.

The best use of alfalfa is to sow grass with it and use it for hay about 3 years and then turn it into pasture. When the pasture is broken for cultivated crops manure should be used liberally, which will return considerable potash. If the land is put back into alfalfa, fertilizer potash should be applied, or at least a test with potash should be made on small areas and if these small areas respond to potash the whole area should be top-dressed. The quick chemical tests for available potash may be made before seeding alfalfa. Potash deficiency in alfalfa is indicated by white or yellowish dots around the tips of the leaves, particularly the lower leaves. In advanced stages of deficiency the lower leaves die and fall off.

As previously stated, too many farmers think that when they grow good alfalfa, clover, and other legumes they improve the soil, even if the manure made from these crops is not returned to the land. Actually this hastens the depletion of all mineral nutrients. It is true that on many soils a treatment with limestone and phosphate, and the growing of legumes following this treatment, greatly increases the yields of such crops as corn, wheat, and tobacco for some time, without the use of fertilizer potash or the return of manure. The chief reason for this is that on most of the depleted soils of the state, the need for calcium, phosphorus, and nitrogen limits crop growth before potash; consequently a light draft has been made on the potash by low crop yields, and when the soil is improved by the limestone-phosphate-legume combination there is usually enough available potash for several large crops. Many farmers fail to realize that this practice rapidly uses up the reserve of available potash and that they should, from the very beginning, conserve and return all crop residues and manure, to prevent the deficiency.

Another practice that causes some loss of potash is the growing of lespedeza without grass seeded with it or without a winter cover crop. When the lespedeza dies in the fall it soon begins to decay, forming acids which may combine with potash compounds in the soil to form soluble potash compounds. Part of the soluble potash then is leached out of the soil in underdrainage water. Grass or a grain cover crop with the lespedeza would use some of this potash and prevent its loss. Such loss may also occur with red clover after harvest if grass is not grown with it. For this reason grass should be sown with clover and other legumes to conserve not only potash but nitrogen also. Lespedeza is grown so extensively in Kentucky that it should be the state's greatest soil-improving and conserving crop, and it can be if grass and cover crops are always used with it and the manure produced from it is properly conserved and used. Cover crops should follow all cultivated crops to prevent the loss of potash and nitrogen by leaching and erosion.

Some Kentucky Experiments With Potash

Residues with cover crop help to maintain potash for corn

Soils and crops workers at the College of Agriculture and Home Economics have long warned farmers that potash deficiencies would occur unless all crop residues and farm manure were carefully conserved and returned to the soil. Experiments started many years ago show the results of such neglect. One of the earliest was on the Experiment Station farm at Lexington, in what was called "The Renewed Experiments," reported in Kentucky Agricultural Experiment Station Bulletin 331 (1932). Two sets of plots containing 10 plots each were used. These plots had been used for fertilizer experiments from 1888 to 1898, during which time the land was poorly drained and in a state of low productivity. The land was partially tile-drained in 1891. Continuous cropping was used and no manure or residues were returned. From the end of the old experiments until the renewed experiments were begun the land was in grass for pasture. A moderate amount of manure was applied to the pasture.

In the old experiments, potash produced large increases in corn yield. When the experiments were renewed in 1914, corn was grown on both sets of plots without any fertilizer, and the average yields of the two sets were the same (43.2 bushels per acre). After that corn was grown continuously on one set of plots without a cover crop and with the cornstalks removed; on the other set a rotation of corn and soybeans was used, with a cover crop each year, and the cornstalks and soybean straw returned to the plots. Both sets of plots were fertilized at the same rate with single elements and various combinations. In the rotation, 7 crops of corn averaged 54.7 bushels per acre for all plots, with no increase from application of fertilizer potash. For the same 7 years the average yield on the plots in continuous corn was 42.4 bushels per acre. On plots where complete fertilizer was used the yield averaged 4.0 bushels per acre higher than where phosphate and nitrogen only were applied. It is interesting that the yield on the plot in continuous corn fertilized with a "complete" fertilizer (460 pounds of approximately 5-5-18) was 49.6 bushels, while on unfertilized plots in the rotation it was 53.1 bushels. The soil of these plots contained from 23,000 to 26,000 pounds of potassium and 5,000 to 6,000 pounds of phosphorus per acre in 7 inches of soil.

Need for additional fertilizer potash for alfalfa

A fertilizer experiment was begun in 1911 on a highly phosphatic, well-drained soil on the Experiment Station farm. This soil contained about 28,000 pounds of potassium per acre in 7 inches of soil. From 1911 to 1931 a rotation of corn, soybeans, wheat, and clover was used. The cornstalks, soybean straw, and wheat straw were returned to the soil except for the first 4 years. Use of fertilizer potash during the period increased the yield of corn 1.0 bushel per acre; soybean seed (16 crops), 0.8 bushel; 6 soybean hay crops, 239 pounds; wheat, 0.1 bushel; 13 clover crops, 319 pounds.

Beginning in 1932 the rotation was changed to corn, wheat, and alfalfa for 2 years. Manure was applied for corn on all plots at the rate of 8 tons per acre. In this test the use of fertilizer potash increased the yield of corn (7 crops) an average of 2.5 bushels per acre; wheat (7 crops), 0.7 bushel; first-year alfalfa (14 cuttings), 294 pounds per cutting per acre; and second-year alfalfa (13 cuttings), 151 pounds per cutting per acre. The alfalfa was generally cut three times a year, but yields were determined only on yields fairly free from weeds. There seemed to be fully as much alfalfa in the weedy cuttings as in the cleaner cuttings, however, and the 200 pounds of muriate of potash per acre applied when wheat was sown thus produced an increase of about 1,335 pounds of alfalfa hay for the 6 cuttings in the 2 years it appeared in the rotation.

Alfalfa requires so much potash (about 50 pounds per ton) that it cannot be grown long upon the same soil without causing a potash deficiency. In a rotation like this it is not advisable to apply enough manure to meet the potash needs of all the crops, including alfalfa; to do so would supply so much nitrogen that it would reduce the nitrogen fixed by the alfalfa. Legumes do not fix nitrogen unless the supply in the soil fails to meet their needs. In a rotation including alfalfa it is better to apply enough manure to meet the potash needs of the nonlegume crops and to apply fertilizer potash for the alfalfa just before seeding. It is best not to grow alfalfa for a long period on the same soil, but rather to grow it in a rotation like the one just cited or to sow grass with it and harvest it for hay for about 3 years and then turn it into pasture. Excellent bluegrass pastures may be produced by this procedure almost anywhere that alfalfa can be grown. After the pasture has been grazed a few years, it may be used for a cultivated crop for 1 or 2 years and then returned to alfalfa and grass. In this way the whole farm may be converted to a grass-livestock type of farming, the type that should be used in Kentucky wherever practical.

Manure-limestone-phosphate vs. limestone-phosphate

At the Mayfield Experiment Field in 1914 two sets of plots of four each were treated alike with limestone and phosphate. A rotation of corn, soybeans, wheat, and a mixture of clover and other legumes and grasses for the fourth year was used through 1931, after which the rotation was corn, wheat, and 2 years of a mixture of legumes and grasses (see Kentucky Agricultural Experiment Station Bulletin 397 for details). The use of manure (applied for corn) on one set of plots and the return of crop residues on the other set was begun in 1916. After 1919 the use of crop residues was discontinued in order to compare the use of limestone, phosphate, and manure with the use of limestone and phosphate only. Alongside these plots was a set of plots on which no limestone or phosphate was applied but to which manure was applied. On both sets of plots on which manure was used it was applied in amounts equal to the weight of crops removed, except the wheat grain.

The set of plots to which no manure was applied produced only 1 bushel of corn less per acre in the first round of the rotation (1914-17) than the set to which manure was applied, showing that there was little difference in the original productivity. (Manure and crop residues were applied only in 1916-17 in this round of the rotation.)

Corn shows potash deficiency to a more marked degree in a rotation like those used in this experiment, and wheat the least. The average yields of crops on the three sets of plots through 1938 were as follows. The last period includes the years after the rotation was changed.

CORN
(Bushels per acre)

Treatment	First 9 crops	Next 9 crops	Last 5 crops
Manure, Limestone, Phosphate	40.7	52.7	50.2
Limestone, Phosphate	36.3	39.2	32.7
Manure	31.6	40.9	43.0

SOYBEAN HAY
(Pounds per acre)

	First 8 crops	Next 8 crops
Manure, Limestone, Phosphate	3482	3603
Limestone, Phosphate	3317	3330
Manure	2581	2991

WHEAT
(Bushels per acre)

Treatment	First 7 crops	Next 7 crops	Last 7 crops
Manure, Limestone, Phosphate	18.6	25.8	21.9
Limestone, Phosphate	17.1	21.1	18.8
Manure	9.2	10.2	11.7

GRASS-AND-LEGUME-HAY
(Pounds per acre)

	First-year hay			Second
	First 7 crops	Next 7 crops	Last 5 crops	year hay (6 crops)
Manure, Limestone, Phosphate	3673	4967	6000	4707
Limestone, Phosphate	3417	3696	4408	3997
Manure	1147	2566	3066	2950

On the plots receiving limestone and phosphate only, the yield of corn rapidly declined as compared with yields on those receiving manure, limestone, and phosphate. As the yields declined, symptoms of potash deficiency developed in the corn. When potash deficiency occurs the lower corn blades turn brown at the tips and edges. As the deficiency increases this condition extends toward the midribs, and leaves higher up on the stalks are affected. In extreme cases the lower leaves die. In 1937 the manure-limestone-phosphate plot produced 52.6 bushels per acre, and the limestone-phosphate plot produced 29.3 bushels. When the corn was planted that year, part of the limestone-phosphate plot was liberally fertilized with potash, and on that part of the plot the yield was 52.1 bushels per acre. This is a most convincing example of the importance of conserving and using manure as a source of potash. In this experiment the amount of manure used was only two-thirds of the possible production of manure. On the average, 1½ tons of manure are produced per ton of feed and bedding. All the manure cannot be accumulated in the barn because much of it is dropped on pasture. This can be made effective by dragging pastures to scatter it.

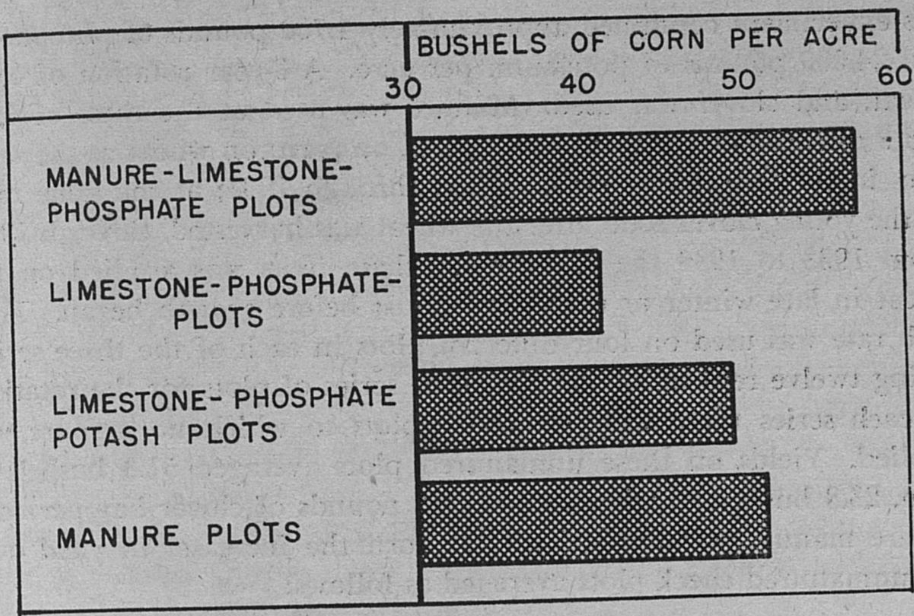
Limestone-phosphate-potash vs. limestone-phosphate

In 1940 the limestone-phosphate plots of the foregoing experiment were divided and half of each was liberally fertilized with potash but no manure was used. The average acre-yields of corn for 1940-42 were as follows:

	bu
Manure-limestone-phosphate plots	57.1
Limestone-phosphate plots	41.2
Limestone-phosphate-potash plots	49.4
Manure plots	51.2

These yields show two very important things — (1) the importance of potash, and (2) that because of the deficiency of nitrogen where manure or nitrogen fertilizers are not used, high yields of corn cannot be produced even though potash is used liberally. Kentucky farmers should beware of developing farming systems in which they will have to depend upon large amounts of commercial nitrogen and potash. A grass-livestock system of agriculture reduces to a minimum the need for purchase of potash and nitrogen. In grass-livestock farming such purchases are usually necessary only for crops of high acre-value, like tobacco. On a few soils in the state that are naturally low in potash, fertilizer potash is needed for other crops also.

One fact that stands out in the results from the various experiment fields is that even when manure equal to the weight of crops taken from the land is returned, the manure will not meet the potash



Corn Yields in Experiments at Mayfield, 1940-42

For high yields, corn must have plenty of potash. Manure returned to the land supplies not only the needed potash, but nitrogen also. A grass-livestock system of farming therefore reduces to a minimum the need for purchase of potash and nitrogen.

needs of all the crops in the rotation indefinitely. For some time it will meet the needs of the corn crop (to which it is usually applied) and the wheat crop following, but the clover and grass crops farthest removed from the application will sooner or later show a deficiency. The only way to put off the time when this deficiency will occur is to feed animals under shelter and save and use the manure, and to drag the pastures to scatter manure. When livestock cannot be on pasture that furnishes worth-while grazing, they should be kept under cover. The barnyard is a source of great loss of manure on many farms. If saving and use of manure does not meet the needs for potash, then fertilizer potash should be used. The manure and crop residues from the increased yields should be carefully saved and utilized so as to recover as much as possible of the purchased potash.

Amount of manure and time of application in rotation

In 1920 an experiment was begun on the Experiment Station farm at Lexington to test the effect of different rates of manure applied at different times in the rotation. The plow layer (7 inches) of soil for this experiment contained approximately 4,700 pounds of phosphorus and 24,000 pounds of potassium per acre. A 3-year rotation of corn, wheat, and clover was used. Manure was used at the rates of 4, 6, and 8 tons per acre, on duplicate plots, on corn; on wheat at the same rates in the late fall or early spring, through 1933; at the same rates on the young clover soon after the wheat was harvested, through 1933. From 1933 to 1938 the manure for these plots was applied on the wheat in late winter or early spring just before growth began. Thus each rate was used on four different plots in each of the three series, giving twelve replications in the three series of plots for the rotation. In each series there were six check plots to which no manure was applied. Yields on these unmanured plots averaged 51.3 bushels of corn, 23.8 bushels of wheat, and 3,375 pounds of clover hay per acre. Where manure was applied on the corn the increases in yield over the unmanured check plots averaged as follows:

	Increase per Acre		
	Corn (bu)	*Wheat* (bu)	*Clover hay* (lb)
4 tons manure per acre	13.1	2.8	346
6 tons manure per acre	14.2	4.0	611
8 tons manure per acre	15.6	4.3	832

Where the manure was applied on wheat or clover but not on corn, the increases were as follows:

	Increase per Acre		
	Corn (bu)	*Wheat* (bu)	*Clover hay* (lb)
4 tons manure per acre	9.5	3.2	792
6 tons manure per acre	9.1	4.0	910
8 tons manure per acre	8.8	4.5	926

Wheat yields were thus about the same whether the manure was applied on the corn or on the wheat or clover. Increases in corn yields were definitely greater where the manure was applied on the corn; and increases in yields of clover hay averaged about 300 pounds greater where the manure was applied on the wheat or clover.

These lower yields of corn following application of manure on wheat or clover than following applications on corn are very significant. As corn in the rotation followed clover, supposedly a soil-building crop, it might be expected that the corn would benefit from the greater growth of clover where the manure was applied on wheat or clover.

The writer believes the explanation is as follows: The clover had a larger use of potash where manure was applied on the wheat or clover, and therefore the yields of clover were higher. But the manure applied to wheat or clover supplied so much nitrogen that the clover did not fix as much nitrogen as where the manure was applied to corn, and consequently there was not so much nitrogen available to the corn as if the manure had been applied for the corn. Also, there may have been less potash available to the corn where the manure was applied to the wheat and clover—but this is of secondary importance, as shown by the following experiments in which there was little increase in corn for potash the first three years where 8 tons of manure had been used on wheat and clover.

Beginning in 1939, manure was discontinued on all plots, and each plot, including check plots, was divided in half and potash applied liberally to one half when corn was planted. The first year potash was used, the average yields of corn were as follows (includes all plots):

	Buhels of Corn per Acre		
Former. manure Treatment	*No potash applied*	*Potash applied*	*Increase for potash*
None	38.3	48.1	9.8
4 tons	47.8	53.0	5.2
6 tons	51.4	54.2	2.8
8 tons	56.8	57.6	0.8

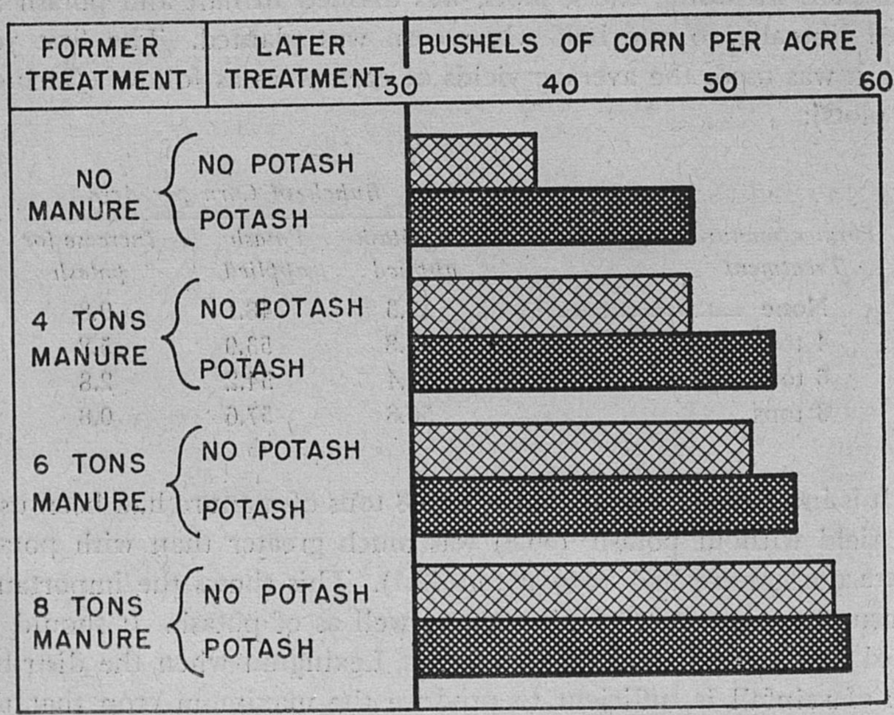
It is interesting to note that where 8 tons of manure had been used the yield without potash (56.8) was much greater than with potash where no manure had been used (48.1). This shows the importance of manure as a source of nitrogen as well as of potash. It should be stated that there is seldom a season at Lexington when the distribution of rainfall is sufficient to produce the maximum crop that the fertility of the soil will permit, although the total rainfall may be high. In 1942 when there was well-distributed rainfall the yield was practically double the yield of 1939, although the crop was 3 years farther away from the last application of manure.

The average increases of corn for potash the first 3 years after the use of manure was discontinued were:

	Bushels per Acre (increase)
Where no manure was used previously	6.5
Where 4 tons manure was used previously	3.3
Where 6 tons manure was used previously	2.3
Where 8 tons manure was used previously	1.3

Approximately 11 tons of manure could have been produced from the crops grown on the plots treated with 8 tons. In a good livestock system of farming the extra 3 tons of manure would have been dropped on the pasture.

The increase for potash the first year as compared with the first 3 years' average looks a little strange, but the following facts are



1939 Yields of Corn in Experiments at Lexington

Manure had been applied once in each 3 years during the preceding 18 years, but was discontinued in 1939, and potash was supplied instead to half of each plot. The more manure used, the higher the yield and the less the advantage from use of fertilizer potash.

significant. Preceding the corn crop of 1939 there was very little second-crop clover to plow under for corn. Preceding the crop of 1940, there being no red clover, a cover crop of crimson clover was seeded and turned under for corn. For the 1941 crop there was some second-crop red clover to plow under for corn, though it was not heavy. The important lesson in this is that catch crops of legumes or other crops draw upon the soil for available potash, and when these crops are turned under a large part of the potash in them is available for the corn, thus supplying the corn with more potash (and also nitrogen) than if the cover crops had not been grown. This contributes to a more rapid depletion of potash by the corn crop than if the catch crop had not been grown. The lesson is to grow the cover crops and conserve all manure and crop residues.

Unfortunately records were not obtained for all the plots in 1944, and a comparison of a second 3 years with the first 3 years after manure was left off cannot be made. The average increases of corn for potash in 1942-43 were as follows:

	Bushels per Acre
Where no manure was used previously	14.9
Where 4 tons manure was used previously	13.4
Where 6 tons manure was used previously	9.6
Where 8 tons manure was used previously	7.8

These increases were on much higher yields than for the first 3 years because the seasons were better. However, the percentage increase for potash has some significance. Where no manure had been used it was 13.4 percent in 1939-41, and 22.8 in 1942-43. Where 8 tons of manure had been used the increase for potash in 1939-41 was 2.3 percent, and 10.5 percent in 1942-43. These results are convincing evidence of the importance of conserving and using all manure and crop residues.

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