No.	Gunning. Per cent.	Modification. Per cent.	No.	Gunning. Per cent.	Modification. Per cent
608	{ 3.70 { 3.75	3.84	767	2.69	2.68
648	4.45	4.45	782	2.64	2.59
659	2.73	2.90	786	1.24	1.18
719	1.48	1.52	793	2.34	2.39
722	3.15	3.09	808	1.98	2.05
723	1.77	1.81	809	1.11	1.07
725	2.73	2.81	819	2.18	2.13
727	2.51	2.52	820	2.27	2.32
731	2.25	2.25	833	2.76	2.83
733	2.90	3.00	888	4.26	4.18
738	6.62	6.50	917	3.07	3.19
742	{ 5.99 { 5.75	{ 5.85 { 5.88	919	2.15	2.17
747	4.30	4.42	924	3.58	3.58
755	3.12	3.22	927	1.91	1.84
756	1.96	2.05	928	2.61	2.58
757	2.88	2.97	933	3.34	3.26
			941	2.90	3.04

Average difference + 0.017.

The greatest difference between the methods is 0.17 per cent. and the average difference is 0.017 per cent. It is advisable to use a little more sulphuric acid in the digestion than is used in the Gunning method. There was no trouble with foaming, turning up the lamps being the only attention required. Time of digestion was about one and a half hours, being about a quarter of an hour longer than in the Gunning method. The modification seems to give as good results, requires fewer chemicals and less attention than the Gunning method, but requires a little longer digestion.

[CONTRIBUTION FROM THE LABORATORY OF AGRICULTURAL CHEMISTRY, OHIO STATE UNIVERSITY.]

NOTES ON TESTING SOILS FOR APPLICATION OF COMMERCIAL FERTILIZERS.[1]

BY H. A. WEBER.

Received September 28, 1899.

FOR more than twelve years of active service in connection with farmers' institutes, the writer endeavored to impress upon the farmers the necessity of a more rational method in the

[1] Read before the meeting of the American Association for the Advancement of Science, August 26, 1899.

use of commercial fertilizers, in order to avoid the useless expenditure of money for plant food which their soil did not require. The means for reaching this result were fully explained, but with few exceptions farmers could not be induced to make for themselves the ordinary field experiments, which alone could inform them of the needs of their soil, and indicate what fertilizers to buy for their fields.

In 1885 the writer instituted a series of experiments with soil in sewer pipes for the purpose of securing a method, by which these soil tests could be made for the farmers at the Ohio State University.[1]

The sewer pipes employed were fifteen inches in diameter and the amount of soil required was about 600 pounds. Subsequently it was found, that by the use of six-inch tiles, the amount of soil required could be reduced to seventy-five pounds with equally satisfactory results. The soils were collected in accordance with the following directions:

1. Never send a sample of soil from a field which without fertilizers is capable of yielding a full crop. On a soil of this nature commercial fertilizers will not pay.

2. Never send a sample from a field, which is not in a good, high state of cultivation; *i. e.*, which is not well drained, and where the soil when cultivated is not deep and pulverulent. Commercial fertilizers cannot counteract bad physical conditions of the soil.

3. Never send a sample from a meadow or clover sod, but always from fields that are under cultivation.

4. If a field is in a high state of cultivation and still fails to produce more than half a crop, there is good reason to believe that the soil is deficient in one or more of the essential ingredients of plant food. From such a field an average sample of soil should be sent for testing. In order to collect an average sample of the soil proceed as follows:

Begin at one end of the field and cross it back and forth at intervals of eight or ten paces until the other end is reached. While thus crossing dig a square hole with a spade, every eight or ten paces, down to the subsoil. Cut off a slice about two inches thick from the surface down to the subsoil and throw it

[1] See Fourth Annual Report, Ohio Agricultural Experiment Station, p. 231.

into a wagon-bed. Better still cut out a core of soil with a post-hole digger at each point. Avoid all local contaminations, as the droppings of cattle, piles of decaying vegetable matter, etc. Remove any trash from the surface by scraping before digging the hole, or sinking the post-hole digger. Also avoid all low places in the field, especially if they are filled with black soil or leaf mold. Thoroughly mix the soil thus collected and send not less than seventy-five pounds for testing. The test is made in the following manner:

Ordinary six-inch tiles are placed into large Wagner pots, which contain enough clean sand so that the top of the tiles will be on a level with the top of the pots. The whole is then filled with sand with the exception of the upper seven inches of the tiles. The sand is then thoroughly drenched with rain or condensed water. The empty portion of the tiles are next filled to within an inch of the top with the thoroughly mixed sample of soil, the fertilizer is added and incorporated with the upper portion of the soil by stirring, moistened if necessary, fifteen seeds of oats, spring barley, spring wheat, or other grain are distributed uniformly over the surface, and then covered with enough of the dry soil to bring the surface of the soil on a level with the top of the tiles. The six-inch tiles, to the depth of seven inches as described, will contain about ten pounds or five kilograms of soil.

Five miniature plots are thus prepared for each soil test. If Wagner pots are not available, a box eighteen inches deep with an opening in the bottom for drainage, and large enough to hold five of the tiles, may be employed. The sand surrounding the tiles is kept moist, by adding water once a week.

The amount and kind of fertilizer to be added to the five plots for each test are as follows:

PLOT 1. COMPLETE FERTILIZER.

	Gram.
Superphosphate	1.0
Potassium sulphate	0.5
Sodium nitrate	0.5

PLOT 2. COMPLETE MINERAL FERTILIZER.

	Gram.
Superphosphate	1.0
Potassium sulphate	0.5

PLOT 3.

	Gram.
Superphosphate	1.0
Sodium nitrate	0.5

PLOT 4.

	Gram.
Potassium sulphate	0.5
Sodium nitrate	0.5

PLOT 5.

No fertilizer.

As examples of this method of testing soils three experiments recently made will suffice.

The three soils were arranged in series of five plots and fertilized as already described. April 29 fifteen oat seeds were planted in each plot. Plants were up on May 3. No difference in the growth of the plants could be noticed before May 16. At this date plots 1, 2, and 3 were alike in all cases and were in advance of plots Nos. 4 and 5. The plots were thinned out to ten plants per plot. On May 18 each plant of plots 1, 2, and 3 had one side shoot, while plots 4 and 5 had none. The difference in growth between plots 1, 2, and 3 and plots 4 and 5 was very marked. On May 22 the plants of plots 1, 2, and 3 had two side shoots and were all practically alike, while plots 4 and 5, which again were alike, had no side shoots, were much smaller and less vigorous. On May 29 the same relation as to growth existed, except that in the case of soils 1 and 2, plot 2, which contained no sodium nitrate, showed nitrogen starvation, and remained in this condition to the end of the experiment. Plot 2 of soil 3 did not reveal nitrogen starvation in the slightest degree, but was in every respect equal to plots 1 and 2.

The plants of plots 4, which contained potassium sulphate and sodium nitrate, were not larger and not more vigorous at any time during the experiment, than those of plots 5, which contained no fertilizer.

From this it will be seen that soils 1 and 2 were deficient in phosphoric acid and nitrogen, while soil 3 was deficient in phosphoric acid only.

The following recommendations were made in accordance with these results: For soils 1 and 2, superphosphate 300 pounds and sodium nitrate 100 pounds per acre. For soil 3, superphosphate 300 pounds per acre.

In the place of superphosphate a like amount of fine bone-meal was recommended for fall crops, like fall wheat and rye. In making the tests of soils in this manner it is not necessary to bring the plants to maturity, if time will not permit. Observations made on the growth of the plots during five or six weeks, will give sufficient data to interpret the needs of the soil.

The tests thus carried out are much less laborious than an analysis of the soil would be, and the chemist, who occupies a position, where the demands for soil analyses are frequently made by persons not properly informed in the matter, may often find this method of use in imparting that knowledge to the farmer, which will enable him to apply commercial fertilizers to his soil in a rational manner.

ON THE UNIVERSAL DISTRIBUTION OF TITANIUM.

BY CHARLES BASKERVILLE.

Received September 8, 1899.

THE universal distribution of titanium in the mineral and plant world is practically acknowledged. V. Roussel[1] found it in basalt; Aleksiejew[2] in certain clays. Holland[3] found it in certain igneous rocks. Dunnington[4] observed its occurrence in the soil of Albemarle County, Va.; later the same writer with McCaleb[5] found it in sixteen specimens of soil collected from different sections of the United States. Subsequently after having examined a large number of samples of soil collected from all parts of the globe Professor Dunnington[6] asserted its universal occurrence in the soils of the world.

W. A. Noyes[7] found it in a number of Arkansas minerals. Hillebrand has shown its presence in a large number of rocks and minerals collected by the United States Geological Survey. Wait[8] found it in the ashes of several plants and different kinds

1 *Ber. d. chem. Ges.*, 6, 1417, *b*.
2 *Chem. Ztschr.*, Rep. 1896, 261.
3 *Chem. News*, 59, 27.
4 *Proc. A. A. A. S.*, 34, 132.
5 *Am. Chem. J.*, 10, 36.
6 *Am. J. Sci.*, Dec. 1891; *Chem. News*, 65, 65.
7 *J. Anal. Appl. Chem.*, 5, 39.
8 This Journal, 18, 402.