THE STATUS

OF

Soil Fertility Investigations

URBANA, ILLINOIS, NOVEMBER, 1908
"To suppress what one conceives to be the truth, because it does not accord with the views of colleagues, is an enormity hardly conceivable to liberal-minded men."—Committee Report, Page 8.

"The statements in this and other publications of the Bureau of Soils have given opportunity for uncertainty as to what was actually in the minds of the authors, and in an address delivered as President of the Association of Official Agricultural Chemists, afterward published as Circular 105, of the Agricultural Experiment Station of the University of Illinois, Dr. Cyril G. Hopkins justly criticises the above conclusions as not being justified by the facts published."—Charles E. Thorne, Director Ohio Agricultural Experiment Station, Page 55.

"An examination of the Rothamsted publications at hand confirmed the correctness of Dr. Hopkins' quotations and justified his criticism. Nevertheless it appeared best to your committee to write directly to Director A. D. Hall, of the Rothamsted Experiment Station, requesting an expression of his views relative to this matter."—Committee Report, Page 52.

"I have carefully considered Professor Hopkins' address which he had sent to me, and as far as regards the Rothamsted experiments his criticism of Professor Whitney's treatment of our figures is quite justified. I cannot agree with Professor Whitney's reading of the results on the Agdell field in the least. The figures he quotes for wheat are hardly justifiable as approximations and are in spirit contrary to the general tenor of the particular experiment. ** In my opinion the results on the Agdell rotation field *** are directly contrary to Professor Whitney's idea that rotation can do the work of fertilizers."—A. D. Hall, Director Rothamsted Experiment Station, Page 52.

"Your committee is of the opinion that this letter gives abundant justification for the position taken by Professor Hopkins that the theory of maintenance of the soil fertility through rotation of crops is not supported by the data of the Rothamsted Experiment Station as quoted by Professor Whitney, and shows that the Director of the Rothamsted Experiment Station will give as little sanction to Asst. Sec. Hays' statement regarding the matter, as expressed in Cir. No. 22, as he does to the conclusions drawn by Professor Whitney."—Committee Report, Page 53.

"President Hopkins is in no need of vindication by a committee of this association. The facts in the case speak for themselves and every chemist and student of soils whose opinion is at all worthy of respect will amply sustain him in the interpretation of these facts. The unanimous action of the committee was inspired, above all else, by the desire to discharge a duty to those who rely on the association as an authority as to strictly scientific methods of research, and the practical application of the results of such work to agriculture."—Committee Report, Page 9.
THE STATUS OF SOIL FERTILITY INVESTIGATIONS

INTRODUCTION
BY E. DAVENPORT

This circular is published in order that Illinois farmers may know the outcome of the differences between the University of Illinois and the Bureau of Soils of the United States Department of Agriculture in respect to soil fertility.

It is well known that Doctor Hopkins, in company with chemists generally, maintains that some of the chemical elements essential to plant growth exist in most soils in limited amounts; that these amounts can be increased by additions or decreased by successive cropping, and that the one tends to larger and the other to decreasing yields because the amount available for crops is a limited and somewhat definite fraction of the plant food at hand in the cultivated soil or immediately below, although the proportion made available during a season varies greatly with different soils and with different seasonal conditions.

It will be remembered too that Whitney and Cameron of the United States Bureau of Soils took a new and radical view of soil fertility, maintaining in essence that practically all soils not only contain sufficient plant food for large crops but that the supply will be indefinitely maintained without any additions of manures or fertilizers; that the failure of crops, aside from physical or seasonal influences, is due to the injurious effect of toxic substances assumed to be thrown off from the roots of plants and acting as poisons to the same kind of crops; that the toxic exudations of weeds are deleterious to all crops; that the beneficial effect of manures and fertilizers is not due to the plant food they supply, but to their neutralizing effect upon the poisonous properties of these toxic compounds; that the cheapest way to sustain yields indefinitely is by following one crop with another not sensitive to the excreta of the preceding crop; and that the productive power of agricultural lands can be preserved indefinitely by judicious rotations without the use of manures or fertilizers.

The logical conclusion of this theory of the Bureau of Soils is that in practical farming operations all matters of fertility may be neglected, providing only the proper rotations be main-
tained, a doctrine eagerly embraced by farmers on failing lands. These views being circulated freely in Illinois where serious soil studies were in progress and where certain sections were already suffering from depleted fertility, the University felt obliged to protest against teachings that were not only new and extremely radical but calculated, if erroneous, to do infinite damage, the objection resting on the ground that the conclusions were not warranted by the data presented and that the promulgation of so dangerous a doctrine should at least be postponed until more conclusive data could be produced.

The burden of this protest naturally fell upon Doctor Hopkins, in charge of the soil investigations, and his criticisms were uttered from time to time as made necessary by the repeated demands from Illinois farmers and editors. This was substantially the condition of matters when in 1906 Doctor Hopkins read his address as President of the American Association of Official Agricultural Chemists at their annual meeting at Washington.

In this address he reviewed the situation at length, showed the incompleteness of the data, the erroneous conclusions drawn therefrom, and the dangers certain to follow the widespread circulation of a fallacious doctrine when backed by all the force of official federal support.

This address was immediately referred to a committee of seven of the most able chemists of the association charged with the duty of reporting upon these points: Was the president of the Association warranted in speaking of this topic upon such an occasion? Was his treatment of the case and his use of the data accurate and were his conclusions fairly drawn from the data at hand?

The report of the committee unanimously justified Doctor Hopkins at every point, and this circular gives in full the method of work of the committee, the data handled, and their conclusions upon the case.

The publication of this matter is the more important because it was omitted from the proceedings of the Association as published by the Department of Agriculture, although the report was unanimously adopted by the Association of Official Agricultural Chemists.

After the omission of the work of this committee from the published official records of the Association, as printed by the U. S. Department of Agriculture, the bare conclusions of the committee were published in SCIENCE, the organ of the Amer-
ican Association for the Advancement of Science. For want of space the full report was not printed. Besides, SCIENCE circulates but little among farmers, so that such a publication as this circular seems to offer the only means whereby the farmers of Illinois may secure the facts concerning so important a matter.

Aside from this introduction, Circular 123 reprints the work of the committee without comment or further discussion of any kind, the University being fully content for the farmers to have access to the work and the findings of this committee.*

The reading of this report in detail is recommended to those interested in knowing the latest scientific knowledge upon the facts of soil fertility, for here the reader is clearly free from the personal bias of any individual. Certainly no more authoritative statement could be had from any body of scientists in America and, since this committee includes in its findings the best European as well as American data, it may be fairly said that the contention of the University of Illinois as ably voiced by Doctor Hopkins has been tried and passed upon by the highest tribunal before which it can be brought. The conclusions are therefore both interesting and important to Illinois farmers as giving the best obtainable information upon which they may base their system of land treatment.

Furthermore there is a national interest in a question of such tremendous import as soil fertility. In the midst of our enormous agricultural production, so widely heralded by the office of the United States Secretary of Agriculture, and with the continued teaching of a national Bureau that soils do not wear out; and, on the other hand, with the call of conventions and the appointment of national and state commissions on the conservation of land and other natural resources, and with warnings of soil depletion from such men as James J. Hill and from the Syracuse Convention, called to consider the problem, "What to do with twelve thousand abandoned farms in New York State,"—under these conditions, the publication of this circular is both fitting and timely.

E. DAVENTPORT,
Director Agricultural Experiment Station,
University of Illinois.

*The address in question upon which this report is based is printed in Circular 105 of the Illinois Experiment Station.
(1) A statement published in Science, October 23, 1908, summarizing the Report of a Committee consisting of seven* of the leading agricultural chemists of the United States, representing seven different states, and appointed by the Association of Official Agricultural Chemists, to investigate in detail statements made in an address by the President of the Association in opposition to the teachings of the United States Bureau of Soils "that practically all soils contain sufficient plant food for good crop yields, that this supply will be indefinitely maintained," etc., etc. (This address was published as Circular 105 of the University of Illinois Agricultural Experiment Station.)

(2) Circular 22 from the office of the Secretary of Agriculture (Exhibit D), containing statements by Assistant Secretary W. M. Hays and Milton Whitney, Chief of the Bureau of Soils, concerning this address.

(3) Comments by Cyril G. Hopkins (Exhibit E) on Chief Whitney's explanations in Circular 22 from the Office of the Secretary of Agriculture.

(4) Detailed Report (Exhibit K) of the Committee of Seven appointed by the Association of Official Agricultural Chemists to "consider in detail the questions raised in the address and report at the next meeting of the Association".

(5) Extracts from Circular 70 (Exhibit G) of the Ohio Agricultural Experiment Station, by Director Charles E. Thorne.

* The members of the Committee, appointed by the Vice-President of the Association, Doctor John P. Street, Chief Chemist for the Connecticut Agricultural Experiment Station, are as follows:

Doctor L. L. Van Slyke, Chief Chemist for the New York State Agricultural Experiment Station.

Doctor Jacob G. Lipman, Soil Chemist and Bacteriologist for the New Jersey Agricultural Experiment Station.

Dean R. J. Davidson, Professor of Chemistry and Dean of the Science Department of the Virginia Agricultural and Mechanical College and Polytechnical Institute.

Professor B. B. Ross, Alabama State Chemist and Chief Chemist for the Alabama Agricultural Experiment Station.

Doctor F. W. Woll, Agricultural Chemist for the University of Wisconsin Agricultural Experiment Station.

Professor A. M. Peter, Chemist and Head of the Chemical Division of the Kentucky Agricultural Experiment Station.

Professor C. L. Penny, Professor of Agricultural Chemistry in the Pennsylvania State College.
Part I

THE PROCEEDINGS OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS

To the Editor of SCIENCE: The Proceedings of the Association of Official Agricultural Chemists for 1907 have just been published as bulletin No. 116 of the Bureau of Chemistry, U. S. Department of Agriculture. By order of the printing committee of the department, the portion of the proceedings referring to the report of the committee on the president's address, 1906, has been omitted in the bulletin, as was also the president's address itself in the printed proceedings for the preceding year (bulletin No. 105, Bureau of Chemistry, U. S. Department of Agriculture).

It may be stated in explanation of these omissions that the president's address delivered at the annual convention of the association, Nov., 1906, among other matters, discussed recent publications of the Bureau of Soils of the U. S. Department of Agriculture and took decided issue with views set forth therein. The president's address having been published elsewhere (see below) it would seem only right that members of the association and men of science in general, who are interested in the question at issue, or in the larger question of the liberty of free speech, shall be given an opportunity to become acquainted with the report of the committee; on behalf of the committee, I would ask, therefore, that the enclosed portion of the proceedings of the association referring to the report, as prepared by the secretary of the association, be printed in SCIENCE.

University of Wisconsin, Madison, Wis.

F. W. WOLL

In the absence of Chairman Woll, Mr. Van Slyke presented the report in behalf of the committee on the president's address:

Report of the Committee on President's Address (1906):

By resolution of this association at its last convention, it became the duty of your committee, "after consultation with the Secretary of Agriculture, to consider in detail the questions
raised" in the president's address. These duties your committee has performed, and now desires to present the following report and be discharged.

The character of the work assigned us is new and without precedent. The essential facts appear to be that the president of this association, in his inaugural address, speaking on the duty of science to agriculture in guarding against error as well as in discovering truth, expressed views antagonistic to those published by one of the bureaus of the Department of Agriculture and criticized adversely certain of its published doctrines, designating the publications specifically and the bureau by name. These being the facts, as your committee understands them, there seem to be three pertinent questions to be considered:

First, Is it proper for an officer of this association to criticize the published work or doctrines of an institution or of individuals?

Second, Is the association responsible therefor?

Third, Did the president correctly state and construe the facts, observations or statements upon which he based his criticisms?

As to the first question, your committee is of the opinion that liberty of criticism of this sort is entirely proper and, more than this, is necessary to the existence of a scientific deliberative body. Free discussion, such as obtains the world over among scientific men, spoken in convention and printed in journals, is indispensable to progress. To suppress what one conceives to be the truth, because it does not accord with the views of colleagues, is an enormity hardly conceivable to liberal-minded men. This principle, once admitted to govern our proceedings, would put an end to the association's usefulness.

As to the second question, it is the sense of your committee that the association is not in any degree responsible for the views expressed by its members in debate or public addresses. That, beyond enforcing ordinary parliamentary laws and courtesy, the association does not and should not exercise censorship over debate or other discussion. Views expressed by members are to be understood as their personal opinions. The association is responsible only for that which it has authorized by formal vote.

In attempting to answer the third question we have carefully verified the figures and statements quoted in the address, by comparison with the publications from which they were derived and by correspondence with the persons familiar with the investigations under discussion. We find them accurately stated and properly used in a legitimate scientific discussion of matters of the greatest interest and importance to agricultural

1 President Hopkins' address on the duty of chemistry to agriculture, 1906, was published as Circular 105 of the Illinois Station.
chemists. In our opinion, the facts as stated in the president's address are essentially correct.

As supplementary to this report, your committee submits as exhibits to be filed, the following documents bearing upon its work and leading to its conclusion:

A. Letter from Chairman Woll to the Secretary of Agriculture.
B. Answer to same from the Secretary, January 19, 1907.
C. Letter of March 25 from the Secretary transmitting Circular 22.
D. Circular 22 from the office of the Secretary of Agriculture.
E. Statement of Dr. Hopkins in regard to Circular 22.
F. Letter from Director Thorne explaining his position.
G. Circular 70 of the Ohio Station relative to Circular 22.
H. Circular 105 of the Illinois Station, being the president's address, as published in pursuance of the resolutions of the association.
I. Bulletin 167 of the Ohio Station.
J. Farmer's Bulletin No. 257 of the Department of Agriculture.
K. A detailed discussion of the issues involved under question No. 3 above, prepared by Chairman Woll with the assistance of some other members of the committee.

(Signed)
L. L. Van Slyke,
Jacob G. Lipman,
R. J. Davidson,
B. B. Ross,
F. W. Woll, 1
A. M. Peter, 1

Mr. Lipman spoke at some length concerning the necessity of the association fulfilling its duty both to the farmer and to the scientific world in taking no equivocal position in regard to the methods of scientific research, approving only such as maintain the highest plane of intellectual integrity and conservatism in the deduction of conclusions from the facts.

President Hopkins is in no need of vindication by a committee of this association. The facts in the case speak for themselves and every chemist and student of soils whose opinion is at all worthy of respect will amply sustain him in the interpretation of these facts. The unanimous action of the committee was inspired, above all else, by the desire to discharge a duty to those who rely on the association as an authority as to strictly scientific methods of research, and the practical application of the results.

1 The signature of the absent chairman of the committee, F. W. Woll, and that of A. M. Peter were appended subsequent to the meeting, the report having been submitted to them. The other absent member of the committee, Mr. C. L. Penny, signified his agreement to the report in the main, but took exception to one phase of it, and his name, therefore, does not appear.
of such work to agriculture. The members of the association are not only affiliated with control and research work, but frequently serve also as teachers in our agricultural schools. They should not, therefore, shirk the moral responsibility imposed upon them. A negative attitude could not be assumed in the discussion under consideration, nor could it be honestly ignored.

The report of the committee was adopted by the association.
Part II

(Exhibit D)

UNITED STATES DEPARTMENT OF AGRICULTURE,

Office of the Secretary — Circular No. 22.

REPORT ON STATEMENTS OF DR. CYRIL G. HOPKINS
RELATIVE TO BUREAU OF SOILS.

U. S. Department of Agriculture
Office of Assistant Secretary,
Washington, D. C., March 16, 1907.

To the Secretary of Agriculture:

Sir: By your reference I have investigated certain charges against the Bureau of Soils and Professor Whitney, Chief thereof, made in letters of, and in an address by, Dr. Cyril G. Hopkins, President of the Association of Official Agricultural Chemists, and Professor of Agricultural Chemistry and Agronomy in the University of Illinois.

My investigation has been directed to the charges against the honesty and good faith of Professor Whitney and the Bureau of Soils; without regard to the scientific points at issue between that Bureau and Doctor Hopkins.

In an open letter dated March 26, 1906, addressed to Prof. Chas. E. Thorne, Director of the Ohio Experiment Station, copies of which were sent to the Secretary of Agriculture, Members of Congress, and various station directors throughout the country, Doctor Hopkins charged—

(1) That the field results of the Ohio station, as stated in bulletin 167 of that station, do not agree with the results obtained by the pot-culture and water-culture methods of the Bureau of Soils.

(2) That in order to show an apparent agreement between the results of the field experiments of the Ohio station and the
results obtained by methods of the Bureau of Soils, material data regarding nitrogen cultures had been suppressed by that Bureau.

(3) Inferentially, Doctor Hopkins charged that the Ohio station authorities were not responsible and did not stand for the results set out in Bulletin 167 of that station, and permitted the conclusions to be included in the said bulletin without their indorsement.

After a careful investigation and a thorough examination of the records and correspondence pertaining thereto, I have found that none of the above charges are justified or warranted.

Further, in an address delivered by Doctor Hopkins in Washington, D. C., on November 7, 1906, before the Association of Official Agricultural Chemists, which address was subsequently printed as Circular 105 of the Agricultural Experiment Station of the University of Illinois, the following direct charge was made by Doctor Hopkins:

(4) The statement by Professor Whitney in Farmers' Bulletin 257 of the U. S. Department of Agriculture, in regard to the results of wheat culture and rotation experiments at Rothamsted, is erroneous and misleading.

I have investigated this charge and have gone over the published records of the Rothamsted station. I find that the statement of Professor Whitney, as found in Farmers' Bulletin 257, is fully justified by the said records, and I conclude that the criticism by Doctor Hopkins is not warranted.

In the same address Doctor Hopkins made use of certain figures and results alleged to be shown by Bulletin 70 of the Agricultural Experiment Station of the University of Minnesota. In this connection I think it only fair to submit to you a letter received by me from Harry Snyder, Professor of Agricultural Chemistry, University of Minnesota. The letter reads as follows:

My attention has only recently been drawn to Professor Hopkins's address, just published as an Illinois station bulletin.

He incorrectly discusses some of our Minnesota work. In the Minnesota report to which he refers there is no discussion whatever of the yields per acre, and he has taken the liberty to draw the conclusion that by continuous wheat production without manures, rotation, or special cultivation of the soil, increased yields of wheat are secured, which is not the case, and is not a system that we have ever advocated; in fact, all of our work and experience has shown just the reverse to be true.

He also infers that no analysis was made of one of the plots. This is incorrect. At the time a large number of analyses were
made of the soil at various depths. Different sets of samples were taken by different individuals, so as to determine the extent to which the soil varied in nitrogen content. Other means were also taken to secure strictly comparable results. In preparing the report for the press all of these minor details were omitted, as it was desired to present a report as concise as possible, giving the farmer only the average of the results and the conclusions. All of the old samples we still have on hand in our store room, and the records of the numerous analyses we have made are stored away in our vault. If Professor Hopkins assumed simply for the sake of his argument that no analyses were made, he is entirely wrong, and such a statement is unjust to our experiment station.

Professor Hopkins makes one statement that is in part correct, where he states that the report is not clear as to the comparative depth at which the samples are taken. All of the calculations and conclusions are made on a uniform basis, and this apparent inaccuracy which he claims exists in no way affects the work and conclusions. There is a large amount of interesting data in connection with those experiments relative to the loss and gain of nitrogen of soils which has never been published. In fact, if there is anything in which the work is especially strong, it is in the large number of analyses that have been made.

I have written Professor Hopkins, but get no satisfactory explanation.

I transmit herewith and recommend for publication as a circular of your office a statement in regard to this matter which has been furnished by Professor Whitney. It is to be understood that my conclusions are not based upon this statement, but, as previously stated, are formed from a personal inspection of the records and correspondence.

Respectfully,

W. M. HAYS,
Assistant Secretary of Agriculture.

Approved:

JAMES WILSON,
Secretary of Agriculture.
STATEMENT BY CHIEF OF BUREAU OF SOILS, REFERRED TO IN LETTER OF THE ASSISTANT SECRETARY OF AGRICULTURE

U. S. Department of Agriculture,
Bureau of Soils,
Washington, D. C., March 16, 1907,

Sir: In reply to the points contained in the letter of Prof. Cyril G. Hopkins, March 26, 1906, to Prof. Chas. E. Thorne, and Circular 105 of the Illinois Experiment Station, which you have called to my attention, I submit the following statement:

Professor Hopkins, in his letter of March 26, 1906, to Prof. Charles E. Thorne, recalculates the results of the Ohio Agricultural Experiment Station wheat fields for nine years and those obtained by the Bureau of Soils with pot-and-water-culture experiments, and after commenting on the comparison between these recalculated results makes the following statements:

Considering this almost absolute disagreement between the Bureau of Soils' "rapid-fire" results and the Ohio station's nine-years' field work, it is at least surprising to find that the identical data from which the above tables are constructed can be manipulated so as to furnish figures regarding which the following statements can be made by the Bureau of Soils.***

That Professor Hopkins is wholly unjustified in his comparison between the field results of the Ohio station and the results obtained by the methods of the Bureau and in charging manipulation of the figures is obvious from a careful reading of Bulletin 167 of the Ohio station and the following statement.

The Bureau's work in Ohio, as stated in the Bulletin, was not carried on in the actual soil of the fertility plots, as assumed by Hopkins, since this would have seriously disturbed the condition of the plots, for the reason that it would have required about 200 pounds of soil from each one of the one-tenth acre plots for the examination contemplated. The soil actually used was from an unoccupied piece of land, which had been manured a short time previously, situated about one-half mile from the fertilizer plots, and from a similar piece of land somewhat nearer the plots, but
considered by the Ohio station to be the poorest soil on the ex-
periment station farm. The soils are described on page 98 of 
Bulletin 167 of the Ohio station. Although the soil actually 
used was carefully and specifically described in the bulletin, 
Professor Hopkins undertakes a detailed and direct comparison 
of the results obtained with it to the results obtained on the fer-
tility plots by Professor Thorne, a comparison so obviously im-
proper that it was not attempted by the authors of the bulletin. 

A single set of samples of about 5 pounds each was taken 
from each of the fertilizer plots for a comparative test in the wire 
baskets, but a week of heavy rain and a leaky greenhouse spoiled 
the results. Since, therefore, the only soil available for the 
basket cultures had recently received a heavy application of 
manure, it did not seem advisable to Professor Thorne to make 
any test with nitrates. On the other hand, Professor Hopkins' 
method of calculating what the effect of nitrate would have been 
if used alone by subtracting the results of the separate effects of 
potash and phosphates and attributing the remainder to nitrates 
is wholly unscientific and unjustifiable, and Professor Hopkins 
justified it (page 12, Circular 105 of the Agricultural Experiment 
Station of the University of Illinois) only by stating that it is the 
only method which he could use. However justifiable such a 
method may be for computing money values, it obviously has no 
value in computing fertilizer effects, since it is conceded by all 
authorities that the effects of fertilizers are not usually additive, 
but that the influence of one fertilizer almost invariably modifies 
the effect which a second fertilizer would have, had it been added 
alone. Indeed, the numerous values obtained for nitrogen by 
Professor Hopkins (Table IV, Circular 105) illustrate this point 
remarkably well, the value of nitrogen varying from 0.49 to 5.44, 
and similarly for phosphates and potash salts.

In the bottle-culture work the extracts were made from a soil 
taken from a strip along the ends but outside of the plot de-
voted to the five-year rotation experiments, as well as from plot 
1, the unfertilized plot of the rotation field. With these experi-
ments also, however, it is perfectly obvious that a comparison of 
improperly calculated values obtained by Professor Hopkins can-
not be considered in any way a contradiction of the comparison 
of the observed results made by the authors of Bulletin 167.

Therefore I would state that with the pot culture a direct 
comparison could not be made, and none was attempted, because
of the origin of the soil samples. With the water cultures the observed results do compare with the field-plot results, although the improperly calculated results of Hopkins do not.

In Hopkins' letter to Thorne he makes the following statement:

By some oversight or foresight the test with nitrogen alone is not considered by the Bureau of Soils, ***

Claiming,

It is difficult to imagine a more discordant comparison than is here exhibited, ***

And adding this question,

In case of two marked discrepancies, is it better to suppress both or to submit one and suppress the other?

The charge is based on the fact that no comparison was made between the nine-year field average and the bottle culture in the case of nitrates. The explanation is as follows:

Professor Thorne's experience, as mentioned in his several reports, is that when commercial fertilizers are first applied to the soils at Wooster they readily respond to nitrates, but much less readily to phosphates until after several annual applications, but that with continuous applications the relatively high value of nitrate applications becomes very much lowered, and the results obtained by pot or bottle cultures for nitrates could not be properly compared with the nine-year field averages for nitrates. Therefore, owing to this objection of Professor Thorne's, made previous to the assembling of the data, the authors of the bulletin did not consider it proper to introduce this value into the comparison made in Table 16 of the Ohio bulletin, quoted in Table III, Circular 105, of the Illinois Station.

In the letter from Professor Hopkins under date of March 26, 1906, to Professor Thorne, the following statement occurs, which was also inferentially contained in Professor Hopkins' address before the Association of Official Agricultural Chemists:

I understand, of course, that the Ohio Experiment Station is not responsible for either the work or conclusions of the Bureau of Soils, even though out of courtesy and in unsuspecting honesty you have permitted the publication of these bulletins from your station, the work having been done at Wooster and on Ohio soils.

The reason for sending the party from the Bureau of Soils to the Ohio Experiment Station, and the general terms under which they went, were certainly known to Professor Hopkins.
A similar offer had been made to him to work under his observation and control with the Bureau's methods in his laboratory on some of his field problems.

That he made this insinuation—virtually a charge of discourtesy and dishonesty on our part against the Ohio station—without basis is evident from the following statements:

In December, 1904, a conference was held in my office with several station directors interested in soil investigations, and a proposition was made and accepted that a party be sent out from the Bureau of Soils equipped with the necessary apparatus to make an investigation of the soils, and the manurial requirements thereof at two of the experiment stations where the work could be under the personal observation and control of the directors, and where the methods could be critically examined. Director Thorne, under date of January 2, 1905, wrote me as follows:

One of us understood you to propose only to apply your methods in the investigations at our respective stations to the determining whether one soil is more or less productive than another, while the others understood, or at least assumed, that you expected to endeavor to determine the cause of the difference in productiveness in the hope of being able to suggest practical methods of amelioration in a shorter time than it is possible through the ordinary field test, and that you propose to carry the investigation further than the familiar pot experiment with fertilizing materials in that while using such materials you will also conduct investigations on methods of improving the physical condition of the soil.

If the first understanding should be the correct one, I do not care to go any further in the matter; but if the second assumption is correct, then I shall be glad to assist in carrying on the investigations to the limit of the available resources of our station.

In reply, under date of January 4, 1905, I wrote Professor Thorne a long letter outlining specifically the scope of the work and stating—

The work of the party will be at all times accessible to you or to your assistants, and the results will be turned over to you for your inspection or use at such times as you desire.

On January 6, 1905, Director Thorne wrote—

Your proposition regarding the work on soils at this station is entirely satisfactory to me.

On January 13, 1905, he again wrote that the proposition was satisfactory to the board of control of the Ohio station.
In a letter to one of the other gentlemen who had taken part in the conference and who was about to cooperate with the Bureau I stated in even more specific terms the purpose of sending the parties to these stations—

You are entirely correct in stating that it is my earnest wish to have our methods of work and outline of thought and reasoning subjected to a very critical study at some place outside of Washington where the soil conditions and crop yields are known from a long-continued field observation.

In order to make the relation between the Ohio station and the Bureau of Soils still more specific, before the work on the experimental plots at Wooster had been concluded and before the report had been written an informal contract was entered into with the director of the Ohio station, under date of June 2, 1905, covering also the investigation of the Strongsville soils to be undertaken at the request of the director of the Ohio station, in which the following provisions appear:

The party will be located at Wooster, Ohio, but may be temporarily sent to Strongsville or such other locations as the director may find desirable for the proper prosecution of the work.***

In so far as compatible with the proper interests of the work, the members of the party will be subject to the usual regulations of this Department, but the disposition of their working time is at the discretion of the director of the Ohio station, who assumes responsibility for the same.***

The work of the party of the Bureau of Soils shall consist in the application of the wire-basket and water-culture methods devised by the Bureau to such problems presented by the Strongsville soils as the director of the Ohio station may direct. An outline of all proposed work and a weekly report of the progress of the work is to be furnished the Bureau of Soils. The Bureau will give such suggestions, advice, and other assistance as it may deem proper, but the acceptance of any such assistance will be in the discretion of the director of the Ohio station, with whom the responsibility for the work rests.***

Mr. Snyder shall immediately prepare a report of the work of the party of the Bureau of Soils upon the Wooster soils, with such added data and such assistance as the Ohio station and the Bureau may be able to give him. Upon the completion of this report it shall be published as shall be mutually agreed upon, either as a bulletin of the Ohio station or, together with the added introduction by the director of the Ohio station, as a regular publication of the Bureau of Soils.

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1Italics mine. The work on the Strongsville soils has not been criticised, and the reader should not be misled by quotations referring to Strongsville and not to Wooster. E. D.
On October 2, 1905, Mr. Snyder, one of the authors of the bulletin, wrote me—

I am sending the manuscript of the paper on Wooster soils, which Professor Thorne has gone over thoroughly and has added a few notes. I have also added the data from a rotation experiment which has been completed since the paper was written, and which I thought might be worth inserting.

On October 6, 1905, four days later, this manuscript was returned to Mr. Snyder with the statement—

We have gone over the paper and inserted the material suggested by Professor Thorne in what seems to us a very satisfactory way. You will, of course, advise Professor Thorne that this is merely a suggestion on our part, but what seems to us the best disposition of the (his) added material, which we think strengthens the paper.***

We had expected there would be an introduction by Professor Thorne to go with this bulletin, and we would like to be advised if Professor Thorne contemplates such an introduction.****

You will express to Professor Thorne our gratification at the outcome of this work, and ask that a copy of the proof sheets be submitted to us for any suggestions or corrections that may occur to us when the paper is in the form before finally going to press.

On October 18, 1905, Mr. Snyder wrote me that Professor Thorne—

Told me yesterday that he was ready to give the paper on the Wooster soils to the printer as soon as the (his) preface was returned from the Bureau.

The day before, October 17, 1905, I had written Professor Thorne—

I have gone over the preface which you sent me a few days ago, and I think it very satisfactory. I have no suggestions to offer, and the manuscript is returned herewith.

On October 14, 1905, Professor Thorne wrote me as follows:

I have carefully studied the report on the basket-culture soil investigations which have been made by your Bureau in cooperation with this station during the past season, and I believe this method of investigation will be found to be a very useful adjunct to the methods hitherto employed in the study of soils. I am so fully convinced of this point that I shall endeavor to procure for this station the erection of a building to be devoted exclusively to soil investigations, with a view to making use of your method as one of the leading features of the work.
There seems to be no necessity of further comment upon Professor Hopkins' treatment of the Ohio station matter.

In Circular 105 of the Illinois station, however, Professor Hopkins attacks my use of certain Rothamsted data in an address published in Farmers' Bulletin 257 of the U. S. Department of Agriculture. On page 22 of Farmers' Bulletin 257 I made the following statement, based on the Rothamsted results:

In other experiments of Lawes and Gilbert they have maintained for fifty years a yield of about 30 bushels of wheat continuously on the same soil where a complete fertilizer has been used. They have seen their yield go down where wheat followed wheat without fertilizers for fifty years in succession from 30 bushels to 12 bushels, which is what they are now getting annually from their unfertilized wheat plot. With a rotation of crops without fertilizers they have also maintained their yield for fifty years at 30 bushels, so that the effect of rotation has in such case been identical with that of fertilization.

On page 21 of Circular 105 of the Illinois station Professor Hopkins, in referring to this statement of mine, says:

It is embarrassing to offer comment upon these statements. Instead of 30 bushels with the fertilized rotation wheat, the average yield is only 27 bushels per acre; and, instead of 30 bushels with the best fertilized continuous wheat, the average yield is 37 bushels per acre. In other words, the statement "that the effect of rotation has in such case been identical with that of fertilization" is far from the truth.***

Professor Hopkins has apparently only studied the tabulated results and is not familiar with the papers of the Rothamsted station and the early controversy with Liebig, in which they admitted, in reply to Liebig's charge that they were operating on a fertile piece of land, that when they begun their operations their soil was similar to the soil of surrounding farms which were yielding from 25 to 27 bushels of wheat, although they admit that others estimate the average yield at 30 bushels, and that they had purposely farmed this land for a few years so as to rid it of all influence of any previous fertilizers or manures. Lawes and Gilbert's own statement in regard to this matter, as taken from the "Report of Experiments on the Growth of Wheat for Twenty Years in Succession on the Same Land," published in 1864, is as follows:

The experiments have been made upon what may be called fair, average wheat land. But, as the rental of similar land in the immediate locality ranges, and has ranged for many years past, only from 25 s. to 30 s. per acre, tithe free, and its wheat crop under the ordinary management of the district certainly
does not average more than from 25 to 27 bushels per acre once every five years, it is obvious that, in a practical point of view, it can lay no claim to extraordinary fertility or to be ranked on a higher level than a large proportion of the soils on which wheat is grown with a moderate degree of success under a system of rotation and home manuring. Such, in an agricultural or commercial point of view, were the general characters of the land.***

For the experiments upon wheat a field of 14 acres was selected, which had grown turnips, barley, peas, wheat, and oats since the application of manure, and would therefore, according to the ordinary rules of practice, be considered so far exhausted as to require to be remanured before growing another crop.¹

It was thought that a field in such a condition was peculiarly fitted to show in which of the constituents of the crop to be grown the soil had become practically the most deficient by the removal of the five preceding crops, and that, if on some plots of the land, in this agricultural sense exhausted,¹ certain constituents of farmyard manure were supplied separately, on others in combination, and if, on others by their side, the crop were grown respectively without manure, and with farmyard manure itself, the comparative results obtained would far more satisfactorily indicate what constituents were the most exhausted, so far as their available supply for the crop to be grown was concerned, than any analysis of the soil could do. ***

It will be observed that notwithstanding the very favorable report of the year’s crop, the produce in these experiments was, without manure, only 15 bushels, and with farmyard manure scarcely 20½ bushels, of dressed corn, with proportionally small amounts of straw. These low results afford satisfactory evidence that the land was in a condition of practical or agricultural exhaustion;¹ and hence, that it was well fitted for the purpose of experiments the object of which was to show in what constituent or class of constituents the soil had become, by the previous course of cropping, the most deficient, so far as the requirements of the wheat were concerned.

Again, in their “Report of Experiments on the Growth of Wheat, for the Second Period of Twenty Years in Succession on the Same Land”, published in 1865, they say:

The last time this land received any manure was in 1839. The crop, which was then turnips, was followed by barley, peas, wheat, and oats, the last four crops being grown without any manure whatever. In the event of a failure of the clover crop, such a course would not at that period have been unusual in the district, although in those days a top-dressing of soot would, in all probability, have been applied to the wheat. In this case, however, it was not applied; and, even if it had been applied, the land after the oat crop would be considered, agriculturally speaking, to be exhausted.¹

¹ Italics mine.—M. W.
It was at this period that the Rothamsted experiments were commenced,\(^1\) for the purpose of ascertaining what amount of crop the land would yield in wheat, without the aid of manure. ***

The average yield of wheat in Great Britain is estimated by us at 28 bushels and by others at 30 bushels per acre.

The above quotations show that the land was already agriculturally exhausted when the first recorded crop of 15 bushels was obtained, which value Doctor Hopkins uses as the basis for criticizing my statement. They further show that the land had originally yielded 25 to 27 bushels. A much better illustration of this decline in crop production is shown by another experiment quoted on page 54 of the report just mentioned, where the table is given of records from 1863 to 1883, inclusive:

<table>
<thead>
<tr>
<th>Year</th>
<th>Dressed corn in bushels per acre</th>
<th>Year</th>
<th>Dressed corn in bushels per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plot 5, minerals alone</td>
<td>Plot 16, minerals and 172 pounds nitrogen</td>
<td>Plot 5, minerals alone</td>
</tr>
<tr>
<td>1863</td>
<td>19½</td>
<td>55½</td>
<td>1873</td>
</tr>
<tr>
<td>1864</td>
<td>16½</td>
<td>51½</td>
<td>1874</td>
</tr>
<tr>
<td>1865</td>
<td>14½</td>
<td>32½</td>
<td>1875</td>
</tr>
<tr>
<td>1866</td>
<td>13½</td>
<td>17½</td>
<td>1876</td>
</tr>
<tr>
<td>1867</td>
<td>9½</td>
<td>14½</td>
<td>1877</td>
</tr>
<tr>
<td>1868</td>
<td>17½</td>
<td>22½</td>
<td>1878</td>
</tr>
<tr>
<td>1869</td>
<td>15½</td>
<td>16½</td>
<td>1879</td>
</tr>
<tr>
<td>1870</td>
<td>18½</td>
<td>18½</td>
<td>1880</td>
</tr>
<tr>
<td>1871</td>
<td>11½</td>
<td>13½</td>
<td>1881</td>
</tr>
<tr>
<td>1872</td>
<td>12½</td>
<td>13½</td>
<td>1882</td>
</tr>
</tbody>
</table>

On plot 16 the yield of wheat had been forced by heavy applications of fertilizers until it produced in 1863 and 1864 55½ bushels and 51½ bushels, respectively. The plot was then left unmanured, being continuously in wheat, and the yield fell from 32½ bushels in 1865 to 13½, 10½, and 15½ bushels in the last three years, respectively, with similar fluctuations in preceding years due undoubtedly to climatic conditions.

From the foregoing quotations it is clear that the statement that the yield fell from 30 to 12 bushels is entirely justified.

Again, on page 22, Farmers' Bulletin 257, I state—

\(^1\) Italicis mine. — M. W.
In other experiments of Lawes and Gilbert they have maintained for fifty years a yield of about 30 bushels of wheat continuously on the same soil where a complete fertilizer has been used.

To which Professor Hopkins also takes exception in the terms above cited, stating—

Instead of 30 bushels with the best fertilized continuous wheat, the average yield is 37 bushels per acre.

In making this criticism Professor Hopkins takes the average yield of the fertilizer plot giving the highest yield. In Farmers' Bulletin 257 I referred to the fertilizer tests in general terms, using all the results where complete fertilizers were used. In the "Plans and Summary Tables of the Lawes Agricultural Trust", published in 1902, there are seven plots upon which complete fertilizers are used. The average yield for fifty years, from 1852 to 1901, from these plots receiving complete fertilizers, are as follows:

<table>
<thead>
<tr>
<th>Plot</th>
<th>Yield.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Bushels.</td>
</tr>
<tr>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>7</td>
<td>32¼</td>
</tr>
<tr>
<td>8</td>
<td>37</td>
</tr>
<tr>
<td>9</td>
<td>29½</td>
</tr>
<tr>
<td>13</td>
<td>31½</td>
</tr>
<tr>
<td>15</td>
<td>30½</td>
</tr>
<tr>
<td>16</td>
<td>34½</td>
</tr>
<tr>
<td>Average</td>
<td>31½</td>
</tr>
</tbody>
</table>

It will be seen that two of these yields are below the figure used by me, one is practically the same, and four are higher, the actual average of all the plots being 31½ bushels instead of 30 bushels, as I stated. It would have been manifestly unfair to have used the best result cited by Professor Hopkins, namely, 37, to illustrate the generalization I was making in Farmers' Bulletin 257, just as it would have been unfair to have used the lowest, namely, 24.

In regard to the statement of the yield of wheat under rotation being maintained for fifty years at 30 bushels, which statement Professor Hopkins also criticises, it will be seen from the actual figures here given from the Annual Memoranda published by the Rothamsted station in 1901 that such a statement is fully justified.
<table>
<thead>
<tr>
<th>Year</th>
<th>Bushels</th>
<th>Year</th>
<th>Bushels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1851</td>
<td>30½</td>
<td>1879</td>
<td>10½</td>
</tr>
<tr>
<td>1855</td>
<td>37½</td>
<td>1883</td>
<td>33½</td>
</tr>
<tr>
<td>1859</td>
<td>35½</td>
<td>1887</td>
<td>34½</td>
</tr>
<tr>
<td>1863</td>
<td>45</td>
<td>1891</td>
<td>32</td>
</tr>
<tr>
<td>1867</td>
<td>27½</td>
<td>1895</td>
<td>21½</td>
</tr>
<tr>
<td>1871</td>
<td>11½</td>
<td>1899</td>
<td>26½</td>
</tr>
<tr>
<td>1875</td>
<td>24½</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The average for the recorded crops in this rotation for the half century is 28½ bushels, the last five crops since 1883 being, in fact, 33½, 34½, 32, 21½, and 26½, respectively.

The difference in the extremes of the entire series for fifty years, namely, from 45 bushels to 10½ bushels, is approximately 35 bushels, which is greater than the average yield of 28½ bushels for the entire period.

Professor Hopkins further objects that in considering the wheat yield I did not cite the fact that the barley and root crops in rotations did not show results parallel to the wheat.

There seems nothing remarkable that a rotation that would be suitable to and would maintain the yield of wheat would be less well adapted to barley or turnips. It might with justice be asked why, if the soil contains sufficient plant food for an average crop of 28½ bushels of wheat from 1851 to 1899, turnips should starve for lack of sufficient plant food. The failure of the turnip crop may be explained in other ways, but not logically on this ground. According to Sir John Lawes (see Jour. Royal Agric. Soc., Vol. VIII, p. 231), the texture of the soil was too heavy for good turnips or good barley. His actual words are—

The soil upon which my experiments were tried consists of rather a heavy loam resting upon chalk, capable of producing good wheat when well manured, not sufficiently heavy for beans, but too heavy for good turnips or barley.

I submit that Professor Hopkins was wholly unwarranted and unjustified in the statements and charges he has made in the letter and circular above referred to.

Finally, I would submit to your attention that it is entirely improper to make public documents a vehicle for personal and political attacks. It is equally improper to use an official position in a National organization affiliated with the U.S. Department of Agriculture as an opportunity for such personal ends.

Respectfully,

**Hon. James Wilson**, Secretary of Agriculture.

**Milton Whitney**, Chief of Bureau of Soils.
PART III
(Exhibit E.)
COMMENTS ON CHIEF MILTON WHITNEY'S EXPLANATIONS.

BY CYRIL G. HOPKINS, UNIVERSITY OF ILLINOIS.

Circular 22 recently published from the Office of the Secretary of the United States Department of Agriculture and bearing the stamp of the most official authority of a great national department of government, is entitled, "Report on Statements of Dr. Cyril G. Hopkins relative to Bureau of Soils".

It is prepared by Milton Whitney, Chief of the Bureau of Soils, and W. M. Hays, Assistant Secretary of Agriculture, and contains also a letter from Harry Snyder, Professor of Agricultural Chemistry*, University of Minnesota.

With due respect to this national office and with absolute loyalty to scientific truth, I am compelled to assert that this circular is positively misleading and unfair. It should be read in connection with this paper and Illinois Circular 105, which contains all of the tabulated comparisons that were used in my letter of March 26, 1906, to Director Charles E. Thorne, a full copy of which will be furnished to any one officially interested in this discussion.

The statement on the first page of Circular 22, Office of the Secretary of Agriculture, that copies of my letter to Director Charles E. Thorne were sent to "Members of Congress, and various station directors throughout the country", should read to A Member of Congress (as stated specifically and named in the letter of transmission to the Secretary of Agriculture) and to six station directors.

Director Thorne speaks for himself concerning the treatment he has received at the hands of the Bureau of Soils.

For the details touched upon in Professor Snyder's letter, one should read Minnesota Bulletins Nos. 53, 70, and 89, in connection with Illinois Circular 105. A study of these bulletins will

*It is reported that Professor Harry Snyder has recently entered the field of commercial chemistry. E. D.
plainly show that what I have said is not only "in part correct" but entirely correct in every essential point; and that I have done no injustice to Professor Snyder's data or to his discussion of his own work.

In my letter to him from which he says he got "no satisfactory explanation", I said,

"According to your letters you have determined the nitrogen content of samples collected (in 1892) from each individual plot, but I still understand that the percentage which you published for Plots Three, Four, Five, and Six (for example) does not represent the exact percentage of nitrogen contained in each plot, but rather the average of the four."

"If we publish a second edition of this paper, I shall be very glad to have the exact percentages of nitrogen found in 1892 in each of the individual plots. This will enable me to make my tabular statement complete, and, at the same time, I can call attention to the change in the text."

Chief Whitney's explanation that the Bureau's pot cultures should not be placed in direct comparison with the Ohio field results does not in any sense explain the Bureau of Soil's published comparison and erroneous conclusions. (See Ohio Bulletin 167, pages 91 and 119, and Illinois Circular 105, pages 8-10).

Thus on page 91 of Ohio Bulletin 167, the Bureau of Soils says:

"The aim of this work has been to determine how nearly the results given by the Bureau's methods mentioned above, when applied to the Wooster soil, can be correlated with those obtained by Director Thorne in his crop rotation studies in the field. The results obtained, together with a comparison of these with Director Thorne's results from his five-year rotation experiments, and some theoretical discussion of the properties of the Wooster soil, make up the present paper. An excellent general agreement is shown between the results obtained by the basket (pot cultures) and aqueous extract methods on the one hand and those of the plot experiments on the other."

In contrast with the above the following is quoted from Chief Whitney's recent statement in Circular 22 from the office of the Secretary of Agriculture:

"Although the soil actually used was carefully and specifically described in the bulletin, Professor Hopkins undertakes a detailed and direct comparison of the results obtained with it to the results obtained on the fertility plots by Professor Thorne, a comparison so obviously improper that it was not attempted by the authors of the bulletin."

"Therefore I would state that with the pot culture a direct comparison could not be made, and none was attempted,
because of the origin of the soil samples. With the water cultures the observed results do compare with the field plot results, although the improperly calculated results of Hopkins do not.

Quoting again from the Bureau of Soils (Ohio Bulletin 167, page 101) we have the following:

"More comprehensive experiments carried on with extract of another sample of this soil, taken from a strip along the ends of the plots devoted to the five-year rotation experiment, gave further valuable results. This soil sample was compared by means of basket cultures (pot cultures) with the one described and used in the experiments already detailed, and produced approximately the same growth as the latter. The results given in Table IV are therefore comparable with those just given."

It may well be asked: If the Bureau's purpose was to compare the pot cultures with the Wooster field experiments, why were the pot cultures made with soil that was not comparable with the experiment field soil?

Or, if the soil was not comparable, why does the Bureau state that the results from the water cultures "are therefore comparable" to those from the basket, or pot cultures, and that "with the water cultures the observed results do compare with the field plot results."

Chief Whitney criticises me for comparing the Bureau's soil extract cultures with the Ohio field results by computing the effect of one element when used in addition to others, but he ignores the fact that I made all other possible comparisons, including a correct and complete statement of the Bureau's unscientific and misleading table on "order of effectiveness". (See Illinois Circular 105, p. 11-14).

Chief Whitney states that I have used "improperly calculated values" because I have computed the effect of one fertilizer when added after another has been applied; showing, for example, that when the Bureau of Soils used manure alone with a yield of 8.80 grams of green wheat plants, while manure and phosphorus together gave a yield of only 8.10 grams, the effect of the phosphorus was to decrease the yield by .70 grams; whereas in the Ohio field experiments the addition of phosphorus increases the yield of wheat from 6.96 bushels when added alone to 12.45 bushels when applied where other fertilizers have been used.

I submit that it is altogether proper and scientific and absolutely fair by both the Bureau's culture methods and the Ohio field experiments to determine the effect produced by phosphorus
on a soil to which nitrogen or manure has already been applied, the nitrogen or manure alone being also applied to the comparison plots or pots. Also that this method of determining the effect of fertilizers under different conditions has been much used by those who have contributed most in truly scientific soil investigations, including Director Wheeler of Rhode Island and Director Thorne of Ohio with both of whom the Bureau of Soils has made 20-day pot cultures or water extract cultures.

Indeed with many experiments to determine the comparative value of different forms of any element or to determine the value of different elements on the same soil the test is made where other elements have been applied to all plots including the checks.

It is just as proper and scientific to determine the effect of phosphorus on soil where plenty of nitrogen has been applied as on soil which naturally contains plenty of nitrogen.

Probably the most valuable scientific work performed for American agriculture by the Ohio Experiment Station is Director Thorne's ten-years' investigation to determine the effect of phosphorus when applied in addition to farm manure. By this investigation with non-acidulated rock phosphate he has disproved in a most conclusive and scientific manner the teaching of half a century regarding the supposed invariable necessity for acidulating rock phosphate.

Who will say that it is improper for Director Thorne to calculate that as an average of eight years' tests the addition of acid phosphate to farm manure has increased the yield of wheat by 5.51 bushels above the yield with manure alone, and that in the Bureau of Soils pot cultures in wire baskets the addition of acid phosphate to farm manure has decreased the yield of wheat plants .70 grams below the yield with manure alone?

Chief Whitney's late explanation of the reason for omitting the nitrogen test, when comparing the results of two investigations in both of which the test had actually been made, would apply with equal weakness to the test with nitrogen and potassium. It is noted that this test also must be discarded before it becomes approximately true that "with the water cultures the observed results do compare with the field-plot results".

Chief Whitney justifies his statement that Lawes and Gilbert "have seen their yield go down where wheat followed wheat for fifty years in succession from 30 bushels to 12 bushels", on the ground that this land had formerly presumably produced as high
as 30 bushels, and was much exhausted when the experiment began. He quotes from Lawes and Gilbert, thus:

"The last time this land received any manure was in 1839. The crop, which was then turnips, was followed by barley, peas, wheat, and oats, the last four crops being grown without any manure whatever."

Referring to this statement and other records, Chief Whitney says:

"The above quotations show that the land was already agriculturally exhausted when the first recorded crop of 15 bushels was obtained."

As a matter of fact, Chief Whitney's former statement was not only that the decrease had occurred "where wheat followed wheat", but he made this statement in connection with his attempted proof of another very important statement, namely:

"There is another way in which the fertility of the soil can be maintained, viz., by arranging a system of rotation and growing each year a crop that is not injured by the excreta of the preceding crop."

He now shows inadvertently from some Rothamsted literature (which he erroneously assumes I have not seen) that five-sixths of this reduction in productive power was produced under a crop rotation in which the same crop was not repeated for at least five years. In other words, his present position is that the yield did decrease without fertilizers from 30 to 12 bushels, but that 15 bushels of this decrease occurred during five years under a crop rotation, which, according to his own theory, should have maintained the fertility of the soil by avoiding the influence of toxic substances; whereas, the decrease "where wheat followed wheat without fertilizers for fifty years", he now admits was not from 30 bushels to 12 bushels, as definitely stated in Farmers' Bulletin 257, but only from 15 bushels to 12 bushels.

His reference to plot 16 on the Broadbalk field at Rothamsted is interesting only because it shows a yield of more than 50 bushels of wheat when plant food was liberally supplied, which decreased to one-third as much within two years when the plant food was not supplied. Plot 16 was not "without fertilizers for fifty years", but for only nineteen years.

In reviewing his proof that the fertility of the soil is maintained by crop rotation as well as by fertilization, Chief Whitney objects to my considering the yield of the best fertilized plot, insisting that we should consider the average of all plots receiv-
ing "complete" fertilizer, whether adequate or inadequate, and, yet, on the next page he proceeds to select, from the four-year rotation experiments, the highest yielding plot.

Indeed, the plot he selects does not grow a four-year rotation, there being but three crops in four years with one year of fallow, and the wheat crop follows immediately after the fallow year; thus the plant food becoming available in two years is devoted to growing one crop of wheat.

By this method he succeeds in getting a yield for the rotation wheat within three bushels of that for the average of well fertilized and poorly fertilized wheat, from which he concludes, "that the effect of rotation has in such case been identical with that of fertilization".

It should be known, moreover, that Chief Whitney used this illustration, not to show that larger wheat crops are produced after the land has been lying idle for a year, but to lead the reader to understand that this larger yield represents the benefit of the rotation of crops.

It is generous to allow 27 bushels for the rotation, as was done in Illinois Circular 105, this being the average of the four plots, two of which, however, lie fallow a year before growing wheat. Chief Whitney states the rotation has maintained the yield at 30 bushels. He selects the highest data and even then shows only 28½ bushels, while the average of all plots is 27, and the average of the best full rotation plot is 26.4 bushels, or 10.7 bushels less than the average of the best plot receiving "complete" fertilizer.

Furthermore, in making his average of complete fertilizer plots, Chief Whitney has included one plot (No.6) which receives only 43 pounds of nitrogen per acre per annum. This is only two-third as much nitrogen as is actually removed in the wheat crop from the best yielding plot. This might be sufficient to destroy toxic substances, but it is not enough to supply the necessary food required by wheat. In fact twice this application, or 86 pounds, has been inadequate to supply the nitrogen needed by the wheat crop after deducting the loss by drainage, which is usually very considerable, so that a further addition of nitrogen (129 pounds in all) has increased the yield by more than 4 bushels as an average of 50 years, and by nearly 7 bushels as an average of the last 10 years.

Because of these facts, if Chief Whitney is to show that the
fertility of the soil can be maintained by crop rotation as well as by fertilization, he should make his comparison between the best system of fertilization and a system depending truly upon crop rotation, instead of selecting only wheat yields following always a year of fallow cultivation.

The following tabular statement is an exact copy of Table 1, given on page 7 of the 1906 "Guide to the Experimental Plots" published by the Rothamsted Experiment Station:

TABLE 1.—EFFECT OF MANURE ON CROPS GROWN IN ROTATION, AGDELL FIELD. AVERAGE PRODUCE PER ACRE OVER THE FIVE LAST COURSES, 1884-1903

<table>
<thead>
<tr>
<th></th>
<th>O</th>
<th>M</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Un-manured</td>
<td>Mineral Manures</td>
<td>Complete Manure</td>
</tr>
<tr>
<td>Roots (Swedes)</td>
<td>15.9</td>
<td>208.2</td>
<td>399.9</td>
</tr>
<tr>
<td>Barley Grain</td>
<td>15.8</td>
<td>20.0</td>
<td>27.7</td>
</tr>
<tr>
<td>Barley Straw</td>
<td>11.3</td>
<td>12.7</td>
<td>18.5</td>
</tr>
<tr>
<td>Clover Hay*</td>
<td>9.4</td>
<td>35.5</td>
<td>37.8</td>
</tr>
<tr>
<td>Bean Corn t</td>
<td>15.9</td>
<td>28.3</td>
<td>19.6</td>
</tr>
<tr>
<td>Bean Straw†</td>
<td>8.8</td>
<td>17.0</td>
<td>11.5</td>
</tr>
<tr>
<td>Wheat Grain</td>
<td>26.2</td>
<td>36.1</td>
<td>37.1</td>
</tr>
<tr>
<td>Wheat Straw</td>
<td>20.8</td>
<td>31.1</td>
<td>33.0</td>
</tr>
</tbody>
</table>

*Average of 3 courses. †Average of 2 courses.

It will be seen that as an average of the last twenty years in these rotation experiments the fertilization has increased the yield of turnips from less than one ton to more than 22 tons (one Cwt. equals 112 pounds); that the yield of barley is increased from 15.8 bushels to 27.7 bushels; the yield of clover hay (in three courses) from about one-half ton to two tons; the yield of beans (in two courses) from 15.9 bushels to 28.3 bushels (best yield without nitrogen); and the wheat yield has been increased from 26.2 bushels to 37.1 bushels per acre.

As a matter of fact, the total air-dry produce obtained during the last twenty years has been greater from the unmanured continuous wheat plot than from the fallow rotation plot whose wheat yields are cited by Chief Whitney.

The term "misleading" is a mild expression with which to characterize Chief Whitney’s misuse of the Rothamsted data to
prove that soil fertility can be maintained "by arranging a system of rotation and growing each year a crop that is not injured by the excreta of the preceding crop".

Chief Whitney explains that he ignored the reduced yields of rotation turnips and barley because "the texture of the soil was too heavy for good turnips or good barley."

This explanation will scarcely satisfy any one familiar with the data; for the texture of the soil was not too heavy for an average yield of 17 tons of turnips and 44 bushels of barley where properly fertilized, although in the unfertilized rotation the average yield of turnips has been less than one ton, and the average yield of barley has been 25 bushels for the fifty years and only 15.8 bushels for the last twenty years.

Chief Whitney's reference to "personal and political attacks" has absolutely no significance except to befog the reader and to withdraw attention from the merits of a discussion made solely in the interest of American Agriculture.

It is most deeply regretted that it seems impossible to expose the misuse of data and the misrepresentation of facts without giving personal offense.

In order to oppose the erroneous teaching of such widespread publications as Farmers' Bulletin 257, by Milton Whitney, the experiment station circular seems to be the most proper and effective medium of publication, and fortunately the voice of fifty State Experiment Stations is not to be throttled by the censorship of the Bureau of Soils, which has been used so effectively to suppress other publications.

It is also eminently proper first to present such papers as Illinois Circulars 72 and 105 to National Scientific Associations; and, when after discussion and careful consideration, the National Association requests the publication and wide dissemination of the paper, it is certainly not improper to comply with that request.
Part IV.
(Exhibit K).

REPORT OF THE COMMITTEE ON THE PRESIDENT'S ADDRESS,
Association of Official Agricultural Chemists, 1906.

The Committee on the President's Address, A. O. A. C., 1906, begs to present the following report.

The work of the committee has been done under authority of the resolutions adopted by the Association at its last annual meeting, which read as follows:

(1) "In view of the general interest in the subject under discussion to others than agricultural chemists, we recommend that a special edition of the President's Address be published separately from the Proceedings for wide distribution.

(2) "Inasmuch as there is not sufficient time during this convention to give the matter the full consideration it deserves, we recommend that a committee be appointed which shall, after consultation with the Secretary of Agriculture, consider in detail the questions raised in the Address and report at the next meeting of the Association."

In compliance with the instructions embodied in the resolution, the first step taken by your committee was to call the attention of the Secretary of Agriculture to the address, by letter dated Jan. 15th. This letter and Secretary Wilson's replies thereto, dated Jan. 19th and March 25th are attached to this report as exhibits A, B, and C, respectively. The report of Asst. Secretary Hays to which reference is made in Secretary Wilson's letter of March 25th has since been published as Cir. 22 of the Office of the Secretary, and is attached as exhibit D. Professor Hopkins has submitted to the committee a statement in regard to this Circular which is attached as exhibit E, and finally, Cir. 70 of the Ohio Exp. Sta., bearing on the discussion of the results of work done by the Bureau of Soils at that Station, has been issued by Professor Thorne and is also appended to our report as exhibit G. * * * * *
Professor Hopkins in the introductory remarks to his address makes the statement that

"The Association of Official Agricultural Chemists is organized to discover and advance the truth and to point out and discard error, relating to agricultural chemical questions. It is as truly the duty of science to protect agriculture from error as it is to afford new truth."

In this view, which gives the President's justification of the subject matter and arguments embodied in the address, your committee heartily concurs. The declaration appears to us not only sound and wholesome, but timely, and, when taken in connection with the spirit of candor which pervades the address, should have freed the author from any suspicion of malice and made impossible the final utterance contained in Cir. 22 of the Office of the Secretary, which reads:

"Finally, I would submit to your attention that it is entirely improper to make public documents a vehicle for personal and political attacks. It is equally improper to use an official position in a national organization affiliated with the U. S. Department of Agriculture as an opportunity for such personal ends."

If the President's address was in the nature of a personal and political attack it must be granted that it was entirely improper to issue Cir. 22 as an official document from the U. S. Department of Agriculture, entitling it "Report on Statements of Dr. Cyril G. Hopkins Relative to Bureau of Soils", as it cannot be supposed that the Chief of the Bureau of Soils would himself do what he blames President Hopkins for doing. Since this circular was issued as an official document, your committee feels compelled to regard the President's address as in spirit and truth a scientific discussion, looked upon by him as needful and opportune, and so acknowledged by the Department of Agriculture in issuing the Cir. 22 from the Secretary's office. We consider, therefore, that in so doing the Secretary of Agriculture and the Chief of the Bureau of Soils have exonerated the President of the Association from the accusation of making his address a personal and political attack.

In considering the questions raised in the President's address in detail, as directed by the resolutions of the Association, we shall discuss the different portions referring to the work at the Minn., Ohio (Bu. of Soils), and Rothamsted Stations, in the order given.
JETHRO TULL’S POSITION.

On page 3 of the President’s address he draws attention to the writings of Jethro Tull, as compiled by William Corbett in 1822, using the following language:

“Mr. Tull’s main principle is this, that tillage will supply the place of manure; and his own experience shows that a good crop of wheat, for any number of years, may be grown every year upon the same land without any manure from first to last.

Mr. Tull continued his wheat crops to the harvesting of the twelfth upon the same land without manure; and when he concluded his work,... he had the thirteenth crop coming on, likely to be very good.

It is now known that the conclusion drawn by Tull and Corbett was wrong, although, as will be shown later, the theory recently promulgated by the United States Bureau of Soils, ‘that practically all soils contain sufficient plant food for good crop yields’, and ‘that this supply will be indefinitely maintained’ is in accord with the teaching of Jethro Tull. Indeed Tull’s data are perhaps as trustworthy and conclusive as any thus far reported in favor of this theory.”

A. Discussion of Minn. Results. The President’s address next calls attention to some experiments conducted at the Minn. Experiment Station, where wheat, barley, oats and corn have been grown continuously during twelve years upon the same plots without the addition of any fertilizers, and points out, as your committee understands him, that the results with wheat might, although very improperly, be quoted as recent carefully conducted experiments in support of the views expressed long ago by Jethro Tull and lately by the Bureau of Soils. The President says:

“It will be observed, from the yields of Plot No 1, that the Minnesota Station has not only confirmed the results of Jethro Tull, in growing good crops of wheat continuously on unmanured land, for twelve years, but these crops have been grown without the special tillage that Tull considered so essential. Indeed, the Minnesota results show that the yields are increasing, the average of the first six years being 14.7 bushels per acre, while 17.2 bushels are produced as the average of the last six years reported. A theory based upon these yields, which cover twelve years, would show that under continuous wheat culture the average yield would be increased by more than ten bushels per acre with every passing quarter century.”

That the President was using these data to show how conclusions might be improperly drawn in support of a mistaken
judgment is clear from the statement which he makes in the next paragraph which reads:

"While these experiments are being carried on primarily to determine the effect upon wheat yields of continuous wheat culture upon the same land, the information secured only shows that some factor or factors, other than the continuous growing of wheat, have thus far exerted predominating influence upon the production of wheat."

Your committee has considered this portion of the President's address in view of the letter quoted by Assistant Secretary Hays which conveys the impression that the Minnesota data are incorrectly reported, or are used in an unjustifiable manner. The letter of Professor Snyder which Assistant Secretary Hays quotes, relating to this phase of the matter discussed in Professor Hopkins' address, reads:

"He incorrectly discusses some of our Minnesota work. In the Minnesota work to which he refers there is no discussion whatever of the yields per acre and he has taken the liberty to draw the conclusion that by continuous wheat production without manures, rotation or special cultivation of the soil, increased yields of wheat are secured, which is not the case, and is not a system that we have ever advocated; in fact all of our work and experience has shown just the reverse to be true."

Your committee has compared Dr. Hopkins' statements and data with Professor Snyder's published results and find that the yields of wheat are correctly reported from the Minnesota bulletins and there is no question but that the average yield of wheat for the last six years is higher than the average for the first six years, but we do not understand, from Dr. Hopkins' or Professor Snyder's statements, that either of them entertain the idea that this relation of yield was in any way the result of constant cropping. Indeed Professor Hopkins twice states that this cannot be the case, first in the quotation above cited and again on page 7 of his address where he says:

"The chief value of the accumulated data from these special plots, is to emphasize the fact that unknown or uncontrolled factors greatly predominate as an influence in the analytical chemical results, even more markedly than in the crop yields with continuous wheat culture."

In the judgment of your committee, both Professor Snyder and Professor Hays have failed to appreciate the idea which Dr. Hopkins intended to convey, viz: that while the data of the Minnesota wheat Plot No. 1 might be used to support the belief
that "proper tillage may supply the place of manure"; or "that practically all soils contain sufficient plant food for good crop yields", or "that this supply will be indefinitely maintained";—nevertheless, it would be wholly unwarranted to so use them. Doctor Hopkins does not say, and evidently does not think, that Professor Snyder so uses the data.

In that portion of the President's address which relates to the losses of soil nitrogen, as indicated by the data in the Minnesota Bulletins Nos. 53, 70 and 89, already referred to, there is clearly more than a misunderstanding. Professor Snyder, in his letter quoted by Professor Hays, takes exception to Doctor Hopkins' statement of the soil analyses made of the Minnesota experiment plots under consideration. He says:

"He also infers that no analysis was made of one of the plots. This is incorrect. At the time a large number of analyses were made of the soil at various depths. Different sets of samples were taken by different individuals, so as to determine the extent to which the soil varied in nitrogen content. Other means were also taken to secure strictly comparable results."

The statement which Doctor Hopkins makes regarding these soil analyses is as follows:

"On page 254 of Minn. Bul. No. 70 occurs the following statement: 'Plots Nos. 1 and 2 contained, at the beginning of the experiment in 1892, .221 percent of nitrogen, while Plots 3, 4, 5 and 6 contained .211 percent.'

It is apparent from this statement that the nitrogen content of the soil from the two plots, Nos. 1 and 2, was determined either by the analysis of one composite sample or by the average of two or more analyses, while the identical nitrogen content of the soil from the four plots, Nos. 3, 4, 5 and 6, was evidently determined in a similar manner."

Taking the statement which Doctor Hopkins quoted correctly from Bul. No. 70, by itself, the inference which he drew seems to your committee a fair one, but, with Professor Snyder's letter quoted by Professor Hays, it must be regarded as incorrect. Referring to page 1 of Bul. 53 it will be found that Professor Snyder says:

"Before beginning the experiment, samples of soil were taken from each of the plots in the following way: Three points were selected in each plot. Within a radius of 20 feet from each of these points five samples of soil were taken with a post-hole auger, to a depth of nine inches. All of these samples were placed in a large box and thoroughly mixed and then the samples for analysis was taken from the mixed lot of small samples."
On page 3 of the same bulletin the following statement is made:

"In these investigations four determinations of nitrogen were made with each sample. The original samples were analyzed at the time of sampling, kept in sealed bottles, and analyzed again along with the samples taken at the close of the rotation. 40 grams of soil were taken for each determination."

The method of sampling the soil in these experiments explained in Minn. Bul. 58, is further discussed in Professor Snyder's paper, "Studies on the Nitrogen Content of Soils" (See pp. 5 and 6).

Bul. No. 53 states that plots Nos. 1 and 2, also a plot adjacent to No. 1, contained .221 percent of nitrogen and that plots Nos. 3, 4 and 6 contained .211 percent of nitrogen, the statement for Plot 5 being omitted, but in Bulletin No. 70 as quoted by Professor Hopkins, it is definitely stated that plot 5 contained .211 percent of nitrogen at the beginning of the experiment. Your committee understands that because three of the plots have exactly the same amount of nitrogen, expressed in percent to the third decimal place, and four of them another amount agreeing to the third decimal place, he (H.) felt justified in assuming the view expressed above.

It is stated in Bul. No. 53 that the soil samples were taken to a depth of nine inches and that the amount of nitrogen was equivalent to 5400 pounds per acre to this depth. In Bul. No. 70 it is stated that "Plots Nos. 1 and 2, to a depth of nine inches, would contain approximately 7700 pounds of nitrogen, while the remaining plots would contain approximately 7400 pounds." It would seem that the depth nine inches should in this case read twelve inches, because in Bulletin 89, in speaking of Plot No. 2, the statement is made:

"The soil of this plot contained originally about the same amount of nitrogen as Plot No. 1, namely, 7700 pounds per acre to the depth of one foot."

But from a letter received from Professor Snyder we learn that an unfortunate misprint has crept into the statement, as "three quarters of" is left out before "one foot" in the last sentence. With this misleading misprint we cannot wonder that confusion has arisen as to the depth of sampling in this work, so much the more so as the exact weight of dry soil in any of the individual plots, at the beginning or the close of the rotation periods, is not given, so far as your committee has been able to learn from the data contained in the bulletins referred to.
The point which Doctor Hopkins makes, as your committee understands him, is that Professor Snyder's studies of nitrogen losses under continuous cropping and under rotation, as shown in the bulletins describing his twelve years' experiments, are not in themselves sufficiently decisive to warrant the conclusion drawn that the rotations adopted have maintained the nitrogen content of the soil, so that at the end of the twelve years there is, without a doubt, more or even as much nitrogen in the soil of these plots or any of them as there was at the commencement of the experiments. The experiments do show that a material loss of nitrogen has occurred on Plot 1; in Plot 2, where rotation with manure was practiced, at the end of the first rotation the figures show a gain of 245 pounds, but in 1900 there has been a loss of 1045 pounds and, at the end of 1904, 175 pounds more. In the case of Plot 3 there was at the end of the first four years, according to the figures, a gain of but 40 pounds; at the end of 1900 a loss of 490 pounds occurs, with a gain of 850 pounds at the close of the rotation in 1904.

The fact that these data are not yet sufficient to warrant the conclusion that either of the systems of rotation practiced, including manure, has maintained the nitrogen content in the plots, cannot be fully realized without taking into consideration the extreme difficulties met with in duplicating samples of soil from small plots, even though this is very uniform in character. It is seldom that the weights of two adjacent cubic feet of surface soil agree to within .5 of a percent; there is a material increase in weight between the surface and the bottom of the first twelve inches; the nitrogen content decreases from the top down, on the whole; and both the humus and organic matter not humified are generally more or less segregated; so that it is extremely difficult to select two 40 gram samples of soil which shall represent the absolute nitrogen content to within .005 of one percent, and yet an error of .005 of one percent stands for 175 pounds of nitrogen per acre in the surface foot where the weight is 3,500,000 pounds. This being so, smaller differences than 175 pounds must repeat themselves several times in the same direction before they can be held to have critical significance in considering changes in nitrogen content of the soil; and the same reasoning holds true in regard to the unavoidable errors of nitrogen determinations, although it must be granted that by the method of analysis adopted by Professor Snyder, as explained in his paper, Studies on the
Nitrogen Content of Soils, errors in this direction have been reduced to a minimum.

Taking all these matters into consideration your committee feels that Doctor Hopkins' use of the Minnesota data, both in the connection he used them and with the discrimination he exercised, was fully justified, and that Asst. Secretary Hays' course in bringing Professor Snyders' letter into Cir. 22 was as unkind to Professor Snyder as it was unjust to Doctor Hopkins.

B. Work done at Ohio Station. The President's address next considers Bul. No. 167 of the Ohio Station. Professor Hopkins says:

"Another series of soil investigations extending over more than twelve years to this date has been conducted by the Ohio Experiment Station. These experiments include the application of the different commercial elements of plant food, singly and in various combinations. Probably no plot experiments have ever been planned and carried on with greater care than has been given to these by Director Thorne and his associates; and some very definite and valuable results have already been secured.

Recently the Bureau of Soils of the United States Department of Agriculture conducted a series of culture tests with the Bureau's paraffin pot and soil extract methods upon soil taken from these experiment plots of the Ohio Station, the purpose being to ascertain whether the information secured by the Ohio Station from the field experiments, extending over many years could not be essentially duplicated by 20-day cultures in paraffin pots and in soil extracts. The results obtained from the soil at Wooster, Ohio, have been prepared for publication by the Bureau of Soils and published without modification by the Ohio Station as Bul. No. 167.

Because of the damaging influence upon agricultural science and practice that is sure to result from the continued publication of bulletins such as this and others issued directly by the Bureau of Soils, a frank and somewhat complete discussion of the data reported and of the conclusions drawn becomes an imperative duty."

In Cir. No. 22 of the Office of the Secretary, Asst. Sec. Hays, in referring to the matter here under consideration, says:

"In an open letter, dated March 26, 1906, addressed to Professor Charles E. Thorne, Director of the Ohio Experiment Station, copies of which were sent to the Secretary of Agriculture, Members of Congress, and various Station directors throughout the country, Doctor Hopkins charged—

(1) That the field results of the Ohio Station, as stated in Bul. No. 167 of that Station, do not agree with the results obtained by the pot culture and the water culture methods of the Bureau of Soils.
(2) That in order to show an apparent agreement between the results of the field experiments of the Ohio Station and the results obtained by methods of the Bureau of Soils, material data regarding nitrogen cultures have been suppressed by that Bureau.

(3) Inferentially, Doctor Hopkins charged that the Ohio Station authorities were not responsible and did not stand for the results set out in Bul. No. 167 of that Station, and permitted the conclusions to be included in the said bulletin without their endorsement.

After a careful investigation and a thorough examination of the records and correspondence pertaining thereto, I have found that none of the above charges are justified or warranted."

In this circular there is also a statement by the Chief of the Bureau of Soils, which considers, in the form of a reply, both Doctor Hopkins' letter of March 26 to Professor Thorne, referred to by Asst. Sec. Hays and Cir. 105 of Illinois Station. In this statement the following occurs:

"Professor Hopkins, in his letter of March 26 to Professor Charles E. Thorne, recalculates the results of the Ohio Agricultural Experiment Station wheat yields for nine years and those obtained by the Bureau of Soils with pot and water culture experiments and after commenting on the comparison between these recalculated results makes the following statement:

'Considering this almost absolute disagreement between the Bureau of Soils' 'rapid-fire' results and the Ohio Station's nine years' field work, it is at least surprising to find that the identical data from which the above tables are constructed can be manipulated so as to furnish figures regarding which the following statements can be made by the Bureau of Soils.' * * *

The statements to which reference is here made are as follows:

"The general conclusions from the field experiments, both at the beginning in 1894 and in their more advanced stages, are in agreement with those from the experiments carried on by the method of basket cultures and in soil extract. (Ohio Bul. 167, p. 116.)

and

"The results of the two investigations at Wooster and Strongsville leave no reasonable doubt that the paraffin pot method does give results in harmony with the average results obtained by the much longer timed experiment in the field. It thus has unquestionable value as a practical method for investigating the manurial requirements of a soil. (Ohio Bul. 167, p. 122.)"
Professor Whitney, clearly admits the disagreement, in part at least, referred to above to which Doctor Hopkins calls his attention and in explanation he says:

"That Professor Hopkins is wholly unjustified in his comparison between the field results of the Ohio Station and the results obtained by the methods of the Bureau, and in charging manipulation of the figures is obvious from a careful reading of Bul. 167 of the Ohio Station and the following statements.

The Bureau's work in Ohio... was not carried on in the actual soil of the fertility plots.... since this would have seriously disturbed the condition of the plots,... The soil actually used was from an unoccupied piece of land, which had been manured a short time previously, situated about one-half mile from their fertilizer plots, and from a similar piece of land somewhat nearer the plots,... The soils are described on p. 93 of Bul. 167 of the Ohio Station.

A single set of samples of about five pounds each was taken from each of the fertilizer plots for a comparative test in the wire baskets, but a week of heavy rain and a leaky greenhouse spoiled the results. Since, therefore, the only soil available for the basket cultures had recently received a heavy application of manure, it did not seem advisable to Professor Thorne to make any test for nitrates. On the other hand Professor Hopkins' method of calculating what the effect of nitrate would have been if used alone, by subtracting the results of the separate effects of potash and phosphates and attributing the remainder to nitrate is wholly unscientific and unjustifiable...."

By the side of these statements of Professor Whitney it is proper to quote from p. 91 of Ohio Bul. No. 167 the following statement of the Bureau of Soils:

"The aim of this work has been to determine how nearly the results given by the Bureau's method mentioned above, when applied to the Wooster soil, correlated with those obtained by Director Thorne in his crop-rotation studies in the field. The results obtained, together with a comparison of these with Director Thorne's results for his five-year rotation experiments, and some theoretical discussion of the properties of the Wooster soil make up the present paper.

An excellent general agreement is shown by the basket and aqueous-extract method on the one hand and those of the plot experiments on the other."

In contrast with this quotation from Ohio Bul. 167 it is proper to place the more recent statement of Professor Whitney in Cir. No. 22 from the Office of the Sec. of Agr., p. 4:
"Although the soil actually used was carefully and specifically described in the bulletin, Professor Hopkins undertakes a detailed and direct comparison of the results obtained with it to the results obtained on the fertility plots, a comparison so obviously improper that it was not attempted by the authors of the bulletin."

Referring now to this discussion of the data in Bul. 167 of the Ohio Station, it is stated preparatory to considering Table 1, that:

"The first series of basements was planned to determine the effect of the three most important fertilizer constituents: nitrogen, potash and phosphorus and of lime and stable manure. All of these substances were used alone and in combination with one another."

Notwithstanding this statement, phosphoric acid is the only element of the three important fertilizer constituents used alone which is included in the table. As long as the influence of both nitrogen and potash, alone as well as in combination, was actually determined and was one of the main objects of trial, it seems very unwise not to have included the results in the table, even though it might not be desirable to use them in the discussion.

Referring to Table 1 it is said:

"From these data the following conclusions may be drawn:

1. Neither acid phosphate (No. 2, Table 1) nor sulphate of potash (No. 3, Table 1), in the proportion used is distinctly beneficial in itself."

This statement is clearly justified, so far as the acid phosphate is concerned but, as the results for potassium sulfate alone are not included in the table, there is no basis for the conclusion regarding the influence of this fertilizing ingredient unless it be assumed that because the acid phosphate alone had been found to produce no effect, or an injurious one, the effect observed from the use of acid phosphate and sulfate of potash together is legitimately ascribed to the effect of the potash salt. To draw the conclusion from such evidence, however, would seem to be contrary to Professor Whitney's statement quoted above from Cir. No. 22:

"That it is wholly unscientific and unjustifiable to calculate the effect of nitrate by subtracting the results of the separate effects of potash and phosphate and attributing the remainder to nitrate."

In conclusion No. 2 of the bulletin a similar course of reasoning has been adopted with reference to the influence of nitrate of soda. The language is as follows:
"2. Nitrate of soda when used in combination with one or both of the above named salts (Nos. 4, 5, 6 Table 1) produces a well marked increase in growth, the improvement amounting to from 29 to 42 per cent by transpiration and from 46 to 62 per cent by green weight."

The use of the singular form of the verb in this sentence, along with the fact that the influence of neither phosphoric acid nor potassium sulfate were found to be distinctly beneficial, leaves it a fair inference that the observed increases may in the author's opinion be properly attributed to the nitrate used, and yet no results alone appear in the table.

It should be stated in this connection that in discussing the data of Table 1 in Cir. 105 of the Ill. Station and in computing the values for his Table 2, Prof. Hopkins nowhere subtracts the separate effect of one ingredient from the combined effect of two or more ingredients and attributes the remainder to another ingredient if used alone. He subtracts the effect of one ingredient, phosphorus for example, from the effect of a group of ingredients, as NP, and regards the difference as the effect of NP over P, or the effect of NP over KNP. He does not call these differences the effect of N, in the first case and the effect of K in the second.

A critical comparison of the Bureau's Table 1 and of what is said in the bulletin in the conclusions regarding the table with Professor Hopkins' Table 2, relating to the data of the paraffin baskets, will show that the data of Professor Hopkins' Table are only more definite numerical expressions of the statements framed in the conclusions of the Bureau's bulletin and that there is complete accord between the two methods of statement. In other words, Professor Hopkins' table does not contradict the language relating specifically to Table 1 of Bul. 167.

The bulletin's Table 1 shows that P alone, added to ordinary soil decreased the green weight .01 gram and the text statement is that P is not distinctly beneficial. Professor Hopkins' table expresses the same fact.

The Bureau's Table 1 shows that PK, added to ordinary soil increased the green weight .8 gram. The text states that K is not distinctly beneficial. Professor Hopkins' table shows that the effect of PK was greater than P alone by the amount .81 gram (the difference between .8 and -.01).

The Bureau's Table 1 shows that NPK, added to ordinary soil, gave an increase over untreated soil, of 3.6 grams green
weight. The text says NPK produced a marked beneficial effect. The table also shows that NP, added to untreated soil gave an increase of 2.7 grams in green weight. The text says NP produced a well marked increase. Professor Hopkins’ table indicates that NPK produces a gain over NP of .9 gram in green weight (3.6 minus 2.7), etc., etc.

There is an equally close agreement between Professor Hopkins’ results and the data in the Bureau’s Table 1 for the other series, as well as with the text discussing that table and since Professor Hopkins uses the same method in comparing the effects of fertilizers on yields from the field plots, which were placed in comparison with the Bureau’s method, no criticism can be urged on the ground of incorrect methods of calculating the results.

If the soil used for the Bureau’s method was not comparable with the soil of Professor Thorne’s rotation plots, nothing need be said, or should in fact be said, as to agreement or lack of agreement between the effect of fertilizers. Since such a comparison was a definite object in undertaking the work, it is very unfortunate that some plan was not devised by which comparable soils could have been obtained. Since Professor Thorne’s rotation series contained seven plots of one-tenth acre each, to which no fertilizers had been applied during the nine years experimentation, it would appear that soil from the plots would have been more suitable for the study than recently manured soil taken from a field half a mile distant. The removal of thirty pounds of soil from each of seven tenth-acre plots could certainly be accomplished without seriously affecting the plots for further comparative studies.

There is another paragraph in Bul. 167 of the Ohio Station, p. 101, which reads as follows:

“More comprehensive experiments carried on with extract of another sample of this (Wooster) soil taken from a strip along the ends of the plots devoted to the five-year rotation experiment gave further valuable results. This soil sample was compared by means of basket cultures with the one described and used in the experiments already detailed (Bureau’s Table 1, we suppose), and produced approximately the same growth. The results given in Table IV are, therefore, comparable with those just given.”

If the Bureau of Soils had not said in the paragraph just quoted, that the experiments referred to are comparable with those of Table 1, they must at least be admitted to be more speci-
fically applicable to the field plots than those made with soil taken from half a mile distant. The results, therefore, of Table IV may be compared with the field plots as given below, consolidated with Prof. Hopkins’ Table III of Cir. 105, Ill. Station:

“CONSOLIDATION OF TABLES IV AND XII OF OHIO BUL. 167 AND TABLE III (b) OF ILL. CIR. 105.

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Order of effectiveness, omitting Plot 6, NP, because of blanks.

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</tbody>
</table>

In this grouping of tables it has seemed proper to include the nitrogen treatment, notwithstanding Professor Whitney’s explanation for having omitted it; first, because all of the facts are present and it can be omitted by anyone who so desires; second, because in spite of the accusation that Professor Hopkins introduced values which were not comparable, having been improperly computed, it is a fact that he has made absolutely no computation to introduce the nitrogen or any other series different from the computation adopted by the Bureau in constructing its own tables. Table IV is introduced because the soil sample from which the extracts were prepared may be expected to be much more nearly comparable with the field plots in comparison than the soil samples used in Table I. The green weights are introduced with the transpiration because both methods are supposed to indicate the character of the soil and are sometimes, in the bulletin, used interchangeably.
If the nitrogen series is omitted, together with the NP series, in which there are blanks, the relative efficiencies, as indicated by the different methods are as given below.

**TABLE OF RELATIVE EFFICIENCIES.**

<table>
<thead>
<tr>
<th></th>
<th>K</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>NK</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>P</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>PK</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>NPK</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

From this grouping it is seen that the only marked agreement is in the results of the two transpiration values, which agree throughout with themselves, but do not agree with the results of the field trials. Neither is there an agreement between the field trials and the green weights of series IV.

In the table of efficiency given in Ohio Bulletin 167 by the Bureau of Soils the values stand as given in the next table:

**TABLE OF RELATIVE EFFICIENCIES.**

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Fertilizer</th>
<th>Bul. 167 Field Method</th>
<th>Water culture method Transpiration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grain</td>
<td>Straw</td>
</tr>
<tr>
<td>2</td>
<td>P</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>K</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>PN</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>PK</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>KN</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>PKN</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

It is only fair to state that the agreement is much more apparent to the eye in glancing at this table because of the complete duplication of figures in the columns "grain" and "straw" under the field method than would otherwise be the case. By the transpiration data of the water-culture method there are three agreements and three disagreements. They are divided as evenly as could possibly be done. With the paraffin pot results held ineligible as evidence by Professor Whitney because the soil used had been recently manured and was taken from a field half a mile distant from the plots with which the comparison was to be made, and with the evidence equally divided, for and
against agreement of the two methods in the case where the soil is held by the Bureau to be comparable with that of the field plots, there should be no difficulty in deciding in regard to the justice of Professor Hopkins’ contention that there is lack of real agreement between the indications of the Bureau’s methods and the field methods as practiced at the Ohio Station on the rotation series of plots. This conclusion is not in accord with Asst. Sec. Hays’ report in Cir. 22 of the Office of the Sec. of Agr., where he says:

“Doctor Hopkins charged—(1) That the field results of the Ohio Station, as stated in Bulletin 167 of that Station, do not agree with the results obtained by the pot-culture and water-culture methods of the Bureau of Soils.”

And concludes, after stating two other charges:

“After a careful investigation and a thorough examination of the records and correspondence pertaining thereto, I have found that none of the above charges are justified or warranted.”

The second charge Doctor Hopkins is quoted as making is:

“(2) That in order to show an apparent agreement of the field experiments of the Ohio Station and the results obtained by the Bureau of Soils material data regarding nitrogen cultures had been suppressed by that Bureau”.

Nitrogen determinations were made by the Bureau and the result for nitrogen alone is given in Table XII of Ohio Bul. 167. But it is not used in stating the relative efficiencies in Table XVI of the same bulletin. Other data from Table XII were, however, used in constructing Table XVI, and no statement is made showing why this should be omitted. It has been shown above that the disagreement is made almost complete by introducing the nitrogen results in the table of relative efficiencies. Notwithstanding this it should probably be admitted that Doctor Hopkins was hardly warranted in using the specific language:

“By some oversight or foresight the test with nitrogen alone is not considered by the Bureau of Soils.”

We submit, however, that it would have been much more nearly in the spirit of true scientific investigation to have made in the bulletin the explanation which Professor Whitney gives in Cir. 22. The third accusation with which Cir. 22 charges Doctor Hopkins reads:

“(3) Inferentially Doctor Hopkins charged that the Ohio Station authorities were not responsible and did not stand for
the results set out in Bulletin 167, and permitted the conclusions to be included in the said bulletin without their indorsement.

To show Professor Thorne's opinion regarding bulletin 167 Professor Whitney quotes, in Cir. No. 22, of the office of the Sec. of Agr., his letter of October 14, 1905, which reads:

"I have carefully studied the report on the basket-culture soil investigations which have been made by your Bureau in cooperation with this Station, during the past season, and I believe that this method of investigation will be found to be a very useful adjunct to the methods hitherto employed in the studies of soils. I am so fully convinced of this point that I shall endeavor to procure, for this Station, the erection of a building to be devoted exclusively to soil investigations with a view to making use of your method as one of the leading features of the work."

After quoting Professor Thorne's letter Professor Whitney closes his remarks on the work at the Ohio Station, as follows:

"There seems to be no necessity for further comment upon Professor Hopkins' treatment of the Ohio Station matter."

It is, however, only just to call attention to the fact that this is the only reference which Professor Whitney gives in which Professor Thorne expresses any opinion regarding the matter under consideration and that in this letter Professor Thorne's conclusions relate only to the character of the methods used and not to the data which the Bureau obtained with them, or to the conclusions drawn from these data.

Your committee has requested Professor Thorne to express his views regarding the matter under consideration and it submits herewith his letter as a part of its report. In this letter Professor Thorne says:

"I am in receipt of your favor of the 17th (January) and will reply as follows. In the first place I would request a careful reading of my preface to bulletin 167, from which it will be seen that I nowhere accept the wire-basket method as a substitute for field experiments, especially where that method is limited to a single season's work. What I say is this:"

Professor Thorne here quotes from the preface directly and from page 91 of the bulletin and then says:

"Had the Bureau of Soils adhered strictly to the above statement there would have been no reasonable ground for criticism, and while I recognized in the manuscript of bulletin 167 a tendency to claim more than the data justified, I did not consider the matter one which demanded my interference, deeming it sufficient to let the reader draw his own conclusions. It will be
observed that this bulletin is not published in form adapted to
the use of the ordinary farmer, and hence it was not distributed to our general mailing list."

This quotation from Prof. Thorne's letter and the further explanations as to his position in the matter given in Cir. 70 of the Ohio Station (Exhibit G) is a sufficient reply to accusation No. 3, which Asst. Sec. Hays states Professor Hopkins made and which he found to be not "justified or warranted."

C. On the Teachings of the Bureau of Soils in General: The President's address next discusses what he regards the baneful influence resulting from the fallacious and erroneous teachings widely distributed among practical farmers in Farmers' Bulletin No. 257. Professor Hopkins summarizes the teachings of this bulletin in the following language:

"1. All ordinary soils, including so-called exhausted soils, contain sufficient plant food for good crop yields, and this supply will be indefinitely maintained, without the addition of any of the plant food elements.

"2. Most agricultural plants, and probably all of them excrete substances that are poisonous to the plant furnishing the excreta. Weeds are poisonous or excrete substances that are poisonous to agricultural plants. So-called exhausted soils contain substances that are poisonous to all agricultural plants.

"3. The fertilizers we add to the soil have their effect upon these toxic substances and render the soil sweet and more healthful for growing plants. It is through this means that our fertilizers act rather than through the supplying of plant food to the plant.

This is the way stable manure and green manures act. This is the principal office of nitrate of soda, potash, and phosphoric acid.

"These are the plain teachings of Farmers' Bulletin 257. Professor Whitney believes that there are cases in which fertilizers do act as plant food, although he states that among all the hundreds of soil samples examined by the Bureau of Soils, from nearly all sections of the United States, none has been found that is deficient in plant food."

After carefully examining the literature relating to soil fertility published by the Bureau of Soils since, and including, Bull. 22, your committee is of the opinion that the above quoted statements from the President's address fairly represent the teachings of the Bureau of Soils as expressed in its literature. It is furthermore the opinion of the committee that even though these statements be true there is little in the body of agricultural knowledge or in its practice, and less of thoroughly demonstrated sci-
Scientific truth, which at the present time can be placed in their support.

In this connection, however, it is proper to state that your committee heartily approves of the investigations being made by the Bureau on the presence and nature of toxic substances in soils, as well as of other new lines of work there in progress. Although dissenting from the conclusions above stated as having been drawn by the Bureau from this work, we commend the efforts of the Bureau in endeavoring to approach old problems from new points of view.

Further along in the President's address he says:

"There is one other point that I feel compelled to mention: After pointing out the benefits of fallow cultivation, Professor Whitney says: There is another way in which the fertility of the soil can be maintained, viz., by arranging a system of rotation and growing each year a crop that is not injured by the excreta of the preceding crop.

"Exactly the opposite of this is true. The rotation of crops is a means for the depletion of soil fertility even more rapidly than can be accomplished by a one-crop system. Nitrogen is the only plant food element that can thus be added to the soil (an unnecessary addition according to the Bureau's theory), and this only in rotations that include legume crops; and the only soil whose productiveness can thus be maintained (and this usually at low yielding power) is on sloping land whose surface soil is washed away in proportion to the exhaustion of the plant food elements and whose subsoil is as rich or richer than the surface.

"On page 22 of Farmers' Bulletin No. 257, there appears an erroneous and very misleading statement concerning the rotation experiments at Rothamsted, in the following words:

"In other experiments of Lawes and Gilbert they have maintained for fifty years a yield of about 30 bushels of wheat continuously on the same soil where a complete fertilizer has been used. . . . With a rotation of crops without fertilizers they have also maintained their yield for fifty years at 30 bushels, so that the effect of rotation has in such case been identical with that of fertilization."

Referring to this matter Asst. Sec. Hays says in Cir. 22:

"Further, in an address delivered by Doctor Hopkins in Washington, D. C., on November 7th, 1906, before the Association of Official Agricultural Chemists, . . . the following direct charge was made by Doctor Hopkins:

(4) The statement of Professor Whitney in Farmers' Bulletin 257 of the U. S. Dept. of Agr., in regard to the results of wheat culture and rotation experiments at Rothamsted, is erroneous and misleading.
I have investigated this charge and have gone over the published records of the Rothamsted Station. I find that the statement of Professor Whitney, as found in Farmers’ Bulletin 257 is fully justified by the said records, and I conclude that the criticism of Doctor Hopkins is not warranted."

An examination of the Rothamsted publications at hand confirmed the correctness of Dr. Hopkins’ quotations and justified his criticism.

Nevertheless it appeared best to your committee to write directly to Director A. D. Hall, of the Rothamsted Experiment Station, requesting an expression of his views relative to this matter, as he has access to all of the data referred to and is more intimately familiar with them than probably any other man now living. His reply is as follows:

Harpenden, Feb. 4th, 1907.

I have carefully considered Professor Hopkins’ address which he had sent to me, and as far as regards the Rothamsted experiments his criticism of Professor Whitney’s treatment of our figures is quite justified. I cannot agree with Professor Whitney’s reading of the results on the Agdell field in the least. The figures he quotes for wheat are hardly justifiable as approximations and are in spirit contrary to the general tenor of the particular experiment. Comparing the yield of the manured and unmanured plots in the rotation field for the last five completed courses and reducing them to the standard of the manured plot = 100 we get:

<table>
<thead>
<tr>
<th></th>
<th>Unmanured</th>
<th>Manured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swede</td>
<td>4.5</td>
<td>100</td>
</tr>
<tr>
<td>Turnips</td>
<td>59.1</td>
<td>100</td>
</tr>
<tr>
<td>Barley</td>
<td>40.4</td>
<td>100</td>
</tr>
<tr>
<td>Clover or beans</td>
<td>66.0</td>
<td>100</td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In wheat the average on the manured plots is 37.1 bushels per acre, on the unmanured plots 26.2 bushels per acre. Of course 26.2 is a remarkably good return for wheat on land without manure for so long, but as the turnip crop practically fails and the clover or bean crop is also very small there are really only two crops in every four years on the unmanured land. Again, the manured plot only gets its fertilizer once in four years and the wheat is taken after three crops have already been removed since the fertilizer was applied.

Wheat is undoubtedly better able to stand soil exhaustion than any other of the crops we grow; as the results show other crops, particularly the turnips, make a very poor show on the unmanured land under rotation.

The following table shows the results obtained in the last
complete rotation, 1900-1903, and compares them in the case of cereals with the manured and unmanured plots grown continuously.

<table>
<thead>
<tr>
<th></th>
<th>1900 Swedes, Tons Per Acre</th>
<th>1901 Barley Bu. Per Acre</th>
<th>1902 Clover Tons Per Acre</th>
<th>1903 Wheat Bu. Per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rotation</td>
<td>Rotation</td>
<td>Continuous</td>
<td>Rotation</td>
</tr>
<tr>
<td>Unmanured</td>
<td>.79</td>
<td>22.1</td>
<td>5.0</td>
<td>0.00</td>
</tr>
<tr>
<td>Manured</td>
<td>24.00</td>
<td>29.4</td>
<td>27.9</td>
<td>.31</td>
</tr>
</tbody>
</table>

Thus the manured plots under rotation are but little better than those grown continuously. The unmanured rotated plots, however, are now practically cropped only in alternate years, and in the matter of cultivation conditions are all in their favor.

In my opinion the results on the Agdell rotation field, when the comparison between fertilized and unfertilized plots is not complicated by any consideration of other factors introduced by continuously growing one crop on the same land, are directly contrary to Professor Whitney's idea that rotation can do the work of fertilizers...

(Signed) Yours sincerely,

A. D. HALL.

Your committee is of the opinion that this letter gives abundant justification for the position taken by Professor Hopkins that the theory of maintenance of the soil fertility through rotation of crops is not supported by the data of the Rothamsted Experiment Station, as quoted by Professor Whitney, and shows that the Director of the Rothamsted Experiment Station will give as little sanction to Asst. Sec. Hays' statement regarding this matter, as expressed in Cir. No. 22, as he does to the conclusions drawn by Professor Whitney.
PART V

(Exhibit G).

EXTRACT FROM OHIO CIRCULAR 70
DIRECTOR CHARLES E. THORNE.

In the introduction of Bulletin 167 the object of the work was outlined by the Bureau of Soils in the following paragraphs:—

“For many years plot experiments on the problems of productiveness in agricultural soils have been in progress at Wooster, Ohio, on the farm of the Ohio Agricultural Experiment Station. These experiments, carried on under the direct supervision of Prof. C. E. Thorne, have been so carefully planned and have extended over so long a series of years that the recorded results are very valuable for comparative studies.

“The Bureau of Soils, desiring to determine whether the results obtained by its wire-basket and aqueous extract methods of studying the productiveness and manurial requirements of soils were in accord with those secured through plot experiments, found in the records of the Wooster experiments a valuable means to this end.”

I. COMPARISON OF FIELD RESULTS WITH THOSE OBTAINED BY THE BUREAU OF SOILS.

The field experiments, with which it was proposed to compare the wire-basket method, were begun in 1893, in a five-year rotation of corn, oats, wheat, clover and timothy. Five tracts of land were employed, in order that each crop might be represented every season. The work was begun by planting corn on one tract in the spring of 1893 and sowing wheat on another in the fall of that year.

It was deemed advisable to select for the preliminary basket work soil as nearly as possible of the same character as the original soil upon which the field work was located, but which had not been subjected to treatment with fertilizers; accordingly a sample of soil was taken, with my approval, not from the area actually under experiment, but from land of the same general character. I have seen no reason to believe that this point has materially
affected the outcome of the test; but a duplicate test, on a small scale, was made on extracts of soils taken from two of the experiment plots. (Bulletin 167, page 112).

In the wire-basket test on the soil first mentioned the addition of phosphorus seemed to have a depressing effect on the yield, and the Bureau of Soils called attention to the fact that similar depressions had followed the use of this substance in two notable cases in the station's field experiments. Attention was also called to the cumulative effect of the fertilizers in the station's field tests, and it was stated that for this reason the later results obtained in these field experiments should not be compared with those obtained in the basket and bottle cultures (Bulletin 167, page 108) and yet just this comparison was attempted, with bottle cultures, on page 115 of the same bulletin, and on page 116 the following conclusions were reached:

"It appears from these considerations that, while, as in the case of all work of this kind, there are a few discrepancies, the general conclusions from the field experiments, both at the beginning in 1894 and in their more advanced stages, are in agreement with those from the experiments carried on by the methods of basket cultures and cultures in soil extract."

This conclusion is repeated by the Chief of the Bureau of Soils in his preface to Ohio Bulletin 168 (page 122) as follows:

"The results of the two investigations at Wooster and Strongsville leave no reasonable doubt that the paraffin pot method does give results in harmony with the average results obtained by the much longer timed experiments in the field. It thus has an unquestionable value as a practical method for investigating the manural requirements of a soil. But it also has been shown to be a valuable instrument of research which will probably enable plot experimenters in the future to save many years of labor, although in no way can it be regarded as supplanting or depreciating the more certain results which long time plot experiments alone can furnish."

The statements in this and other publications of the Bureau of Soils have given opportunity for uncertainty as to what was actually in the minds of the authors, and in an address, delivered as President of the Association of Official Agricultural Chemists, afterwards published as Circular 105 of the Agricultural Experiment Station of the University of Illinois, Dr. Cyril G. Hopkins justly criticises the above conclusions as not being justified by the facts published.
II. SUPPRESSION OF THE NITROGEN DATA.

Dr. Whitney states, in Circular 22, that it did not seem advisable to me to make any test with nitrates on the soil used for the basket cultures reported in Table 1 of Bulletin 167, thus implying that no such tests were made in that series, although it is stated on page 94 of Bulletin 167 that:

"The first series of baskets was planned to determine the effect of the three most important fertilizer constituents: nitrogen, potash and phosphorus, and of lime and stable manure. All these substances were used alone and in combination with one another *** The results of this series are given in Table 1."

These statements leave us in doubt as to whether separate tests were made with nitrate of soda and muriate of potash; but as to my position in the matter I would say that the very meager effect produced in this station's field experiments by the use of nitrogen or potassium, except when combined with phosphorus, had led me to doubt the usefulness of separate applications of either of these elements on ordinary soils, either in field or laboratory, and because of this doubt such applications have been omitted from the field experiments planned and put into operation during recent years.

This fact, however, that the full effect of a fertilizing element may only be realized when it is combined with one or more other elements, makes some such method of computation as that which Dr. Hopkins has employed essential to a correct understanding of the real outcome of the test. As Dr. Whitney says, in Circular 22:

"*** It is conceded by all authorities that the effects of a fertilizer are not usually additive, but that the influence of one fertilizer almost invariably modifies the effect which a second fertilizer would have, had it been added alone."

This is precisely the point aimed at in Dr. Hopkins' method of calculation. He has not attempted to compute average values for the different elements by his calculation, but shows that the effect of any element will depend upon the combination in which it is used.

III. RESPONSIBILITY FOR CONCLUSIONS.

As has already been stated, Bulletin 167 of the Ohio Experiment Station was prepared by the Bureau of Soils, but was published by the station. In my preface to this bulletin I did not in set terms disclaim responsibility for the conclusions arrived at in the bulletin, assuming that its acknowledged authorship was sufficient on that score.