The meteor was following and overtook the earth, the angle between its path and the direction toward the apex of the earth's motion being 132°. The elements of the orbit with reference to the sun are:

Ω	273° 22′	longitude of ascending node.
i	9° 28′	inclination to the ecliptic.
π	150° 12′	longitude of the perihelion.
$\log q$	9.7937	logarithm of the perihelion distance.
$\log e$	0.6329	logarithm of the eccentricity.

Professor Peck's paper will be printed in full in the *Monthly Weather Review.*

R. L. Faris,
Secretary

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the meeting of February 18, Miss Frances Densmore read a paper entitled "Music of the Chippewa," and used as illustrations many phonographic records secured by her during a season's work for the Bureau of American Ethnology among the Chippewa of Minnesota. Miss Densmore said that the music of the Chippewa is an echo from the land of the pine trees, the lakes and the little hills. All their life is intertwined with music; from babyhood to death the songs of the people express the joys and sorrows of life, the exultation of war, the solemnities of their religion, the tenderness of love and the cradle songs, farewells to the warrior and dirges for the departed. Miss Densmore gave a cradle song, the invitation to a ceremony, a plaintive love song, the requiem of Chief Flatmouth, the song of Wain-ah-bo-zho (who wrung the ducks' necks), and a series of songs of initiation into the Grand Medicine Society, which latter ceremony was described in some detail. At the close of Miss Densmore's paper three Chippewa Indians visiting Washington gave a representation in costume of the initiation of a candidate for membership in the medicine lodge, and the effect of the songs accompanied with the rattle and tom-tom was very striking. The chief also made a speech laudatory of his white friends in Washington, Rev. J. W. Gilfillan interpreting. The paper was discussed by Miss Fletcher and Mr. Wead, and Miss Densmore answered a number of inquiries.

Walter Hough,
General Secretary

DISCUSSION AND CORRESPONDENCE

TOXICITY AS A FACTOR IN THE PRODUCTIVE CAPACITY OF SOILS

The U. S. Department of Agriculture in 1903 promulgated, through its Bureau of Soils, in Bulletin 22, the teaching (1) that practically all agricultural soils contain sufficient plant food for good crop yields and that this supply will be indefinitely maintained; (2) that not only is the soil moisture a natural nutritive solution, but that it has sensibly the same concentration in productive and unproductive soils; (3) that this concentration is by natural processes constantly maintained of sufficient strength to meet the needs of crops giving good yields; and (4) that the good effects observed in all parts of the world to follow the practise of proper rotation of crops, the application of stable and green manures and of mineral fertilizers, must be due to some other mode of action than that of supplying the crop on the ground with needed additional plant food.

During the four years since the publication of these views the Bureau of Soils has devoted much of its time, energy and funds to an attempt to show (1) that crops excrete through their surfaces, and leave in the soils or upon the field toxic substances which, when tilth and climatic conditions are right, are the chief cause of reduced yields and runout lands; and (2) that proper crop rotations, stable and green manures and mineral fertilizers owe their observed good effects on crop yields to destroying or removing these toxic principles rather than to contributing plant food to the crops.

In the support and promulgation of these views there have now been published four other bulletins from the Bureau of Soils and one circular from the office of the Secretary of Agriculture in reply to adverse criticisms made upon them. It is the purpose here to discuss broadly but concisely what basis there may be for these views.

Amount of Plant Food Carried by Soils.

When no distinction is made between the amount of *plant food proper* and the amount of the elements and substances from which plant food may be derived there is no doubt but that the amount present, even in the poorest soils, is very large when measured in units of yearly crop demands. But the amount is not so large, either absolutely or in the rate of renewal by rock weathering, as to be inexhaustible if only it could be made continuously available at the rate required for good yields. Indeed the untruth of an assertion that by establishing good mechanical facilities for a high rate of removal of coal and thorough sanitary conditions for the miners, the supply of coal in a given mine will be indefinitely maintained, is no more certain than the contention that by a proper rotation of crops and the maintenance of good tilth and proper sanitary conditions uniformly large yields may be indefinitely maintained on any and all fields without a return to the soil of the plant food removed. We have in Wisconsin residuary soils whose absolute content of potassium is only 4.6 tons, of calcium 5.3 tons, of magnesium 3 tons, of nitrogen .9 ton and of phosphorus .8 ton per acre-foot of field. But it is very important to recognize that by very far the larger proportion of these plant food elements existing in the soil is, properly speaking, no more to be regarded as plant food for the crop growing upon the ground than it is food for the cattle feeding upon pasture grass, hence there is never present in the soil of a field any such large amounts of plant food proper as have been stated.

But, considering these amounts as capable of being converted into plant food proper as rapidly as large yields of crops would demand, the whole amount of the phosphorus finds its equivalent measure in the amount carried in 268, and the whole of the potassium in but 634, 20-bushel-per-acre crops of wheat, allowing nothing for losses by leaching. And yet the rate of surface erosion which will expose uncropped material from below as rapidly as one foot in 4,000 years could supply phosphorus only one fifteenth and potassium one sixth as fast as would be demanded by the 20-bushel crops of wheat. It follows, therefore, that for the soil in question to have a productive capacity of 20 bushels per acre per annum, indefinitely maintained without the application of phosphorus and potassium, the rate of surface erosion and of subsoil and rock weathering must equal one foot in every 268 years for the phosphorus, and one in every 634 for the potassium. But these are rates seldom if ever experienced in any agricultural region and the mean rate of erosion for the whole Mississippi Valley has been placed by geologists at not more than one foot in 4,000 to 6,000 years.

Nature's method of developing and of maintaining the productive capacity of fields has always been that of returning to the soil the whole crop, but, even so, nowhere has the concentration of the mineral elements of plant food been large as a result of soil formation by rock weathering under plant growth. The reverse rather has been the rule and very emphatically so with lime and magnesia. Only organic matter, with its ash, has at times and places accumulated to form peat and coal but always under non-agricultural conditions. There appears, therefore, no ground for a difference of opinion as to the point that it is possible for a mere rotation of crops, coupled with good tillage, and ample and timely moisture supply, to indefinitely maintain high yields where the whole crop above ground is regularly and continually removed from the field.

Concentration of Soil Solutions.

Notwithstanding the contention made in Bulletin 22 of the Bureau of Soils, and reiterated in later publications from the same office, that all soil solutions have essentially the same concentration, it must nevertheless be admitted that no observations yet published can be regarded as indicating even the approximate concentration of a single soil solution as it exists in the soil and functions in the growth of plants under field, greenhouse or pot culture conditions. It must further be admitted that the water solutions which have been recovered from soils do show a very wide range, in both composition and concentration, when judged by any standard admissible from the cultural point of view.

It is of the greatest importance in the consideration of this question to recognize the fact that neither the water solutions decanted from soil samples, the water filtered through soil, nor the solutions separated from field soil by either natural drainage or a centrifuge represent either the relative composition or the concentration of the portion remaining behind in contact with the soil. The only conclusion which is warranted, based upon existing published data regarding the concentration of soil solutions as they exist under field, plant house and pot culture conditions, is that they are certainly an undetermined amount stronger than would be indicated by the observed concentrations of solutions recovered thus far from soils under such cultural conditions.

It had been demonstrated in the laboratory of the Bureau of Soils, before the data presented in Bulletin 22 had been obtained, that when a coarse, thoroughly acid-cleaned and washed sand known to contain 84.71 parts per million of NO_3 in so soluble a form as potassium nitrate was washed three minutes in twice its weight of water, only 73.7 per cent. of the actual amount present was recovered in the first washing, and after ten consecutive similar washings there was still retained in the moisture films closely investing the sand grains 18.02 per cent. of the original amount given to the sand, which amount was subsequently recovered after rendering the sand water-free. After the sixth washing, in this experiment, the strength of successive solutions became constant at .11 part per million of NO_3, the concentration standing as below:

1 washing	31.210	p. m.
2 washings	3.284	"
3 "	.452	"
4 "	.174	"
5 "	.138	"
6 "	.128	"
7 "	.111	"
8 "	.110	"
9 "	.110	"
10 "	.110	"

Schreiner and Failyer, in Bulletin 32, Bureau of Soils, have since published similar results, working with very soluble phosphates and potassium chloride in connection with several soils. The simplest explanation for results like these is to suppose that these salts are retained in solution within the stationary films investing the sand and soil grains and that the salts recovered by successive washings after the concentrations become constant, measure the rate of outward diffusion from the stationary film into the free water. But the Bureau of Soils holds (and presumably the authors of Bulletin 32) that the fact that, after prolonged leaching of soils with pure water, the filtrate appears to attain a constant concentration, furnishes direct proof in support of the contention that all soil solutions have a concentration sensibly the same, the thought being that certain amounts of the salts experimented with had been absorbed by the soils, which were later redissolved by the excess of water on its passage over the soil grain surfaces. It is to be observed, however, that in the case of the solutions and soils reported upon by Schreiner, the salts retained, even in the case of phosphates, had not become sufficient to make the retained water a saturated solution under conditions not affected by the soil surface action. It must, therefore, be admitted, we think, that the data of Bulletin 32 lends little support, such as is being eagerly sought, in defense of the views of Bulletin 22, to wit, that in all cultivable soils the moisture is a nutritive solution having sensibly the same concentration.

So far is this view from being a demonstrated fact that if the data presented in Bulletin 22 in support of it be admitted in evidence quite the reverse proposition must be counted proved by nearly every table there presented. To illustrate: The data on pages 31, 32 and 33 show a range of soluble phosphoric acid varying from 12 parts per million of soil moisture to 203 parts per million, supposing the water content in each soil sample to be 20 per cent., computed on the dry soil. That this wide range in concentration is not due to exceptional cases is made clear by arranging the data of this table in an ascending series; averaging in groups of ten to reduce errors and unusual irregularities, we get the following series of concentrations: 16.8, 28.8, 37.2, 41.7, 45.4, 50.3, 54.6, 59.8, 64.3, 70.6, 86.7 and 165.8, the last average containing but four analyses.

This table here referred to contains only analyses of a single soil type known as Cecil clay as it occurs in the vicinity of Statesville, N. C., and instead of indicating that all soil solutions have the same concentration, if it proves anything, it shows that even one and the same soil type, as mapped by the Bureau of Soils, may carry solutions of phosphoric acid ranging all the way from 16 to 165 parts per million, if indeed not from 12 to 203 parts.

But from what has been demonstrated regarding potassium nitrate from clean sand, and indeed from the data presented in Bulletin 32, referred to above, there is every reason to think that the first three-minute washing to which these soil samples were subjected should not be expected to give a solution which would indicate the true concentration of the fixed water films investing the soil granules and soil grains, and which must be regarded functional in root feeding, and hence the true difference between the extremes in this series of soil samples should be expected to be much greater than that observed.

During the year of preliminary studies regarding the nature and concentration of soil solutions preceding the collection of the data presented in Bulletin 22 a very carefully selected series of samples of soils was taken by the writer from 67 localities covering 41 of the bureau's soil types, distributed in seven states, each sample being always a composite of four cores taken with the soil tube instead of with the auger. The total water soluble salt content in the surface foot of 66 samples from these soil types were determined by the gravimetric method, the residues being dried at 110° C. before weighing. These results showed an extreme variation ranging from 105 parts per million of soil solution, computed to a moisture content of 20 per cent. of the dry soil, to as high as 1,962 parts; and when this series of determinations is arranged in an ascending order and the analyses averaged in groups of ten the concentrations stand 239.5, 418.1, 546.8, 673.7, 810, 950 and 1,530 parts per million, and when these differences are shown with only three-minute washings in water equal to five times the weight of the soil, in its fresh, normal field condition, a liter of the solution being evaporated in each case, it is difficult to understand how such data, originating in the bureau, should have been ignored in drawing conclusions so at variance with the experimental records. In the case of the phosphoric acid for this series, which was determined for each of the surface four feet separately and the data published in Bulletin 26 of the bureau, the extreme range of phosphates is from 1.64 to 39.56 parts per million, and when grouped and averaged in tens as in previous cases, the results are 3.64, 6.65, 9.65, 12.43, 17.57, 26.73 and 35.56 parts per about 4,000,000 of dry soil. In Bulletin 26 there are also given data from various sources regarding drainage waters from England, analyzed by Way, Frankland and Voelcker, all of which show strong differences in the concentration of soil moisture as it leaves natural field soil by way of underdrains. It must be conceded, therefore, that there is no good foundation in observation or, indeed, from *a priori* considerations, for the contention that all soil solutions have essentially the same composition and concentration when viewed from the standpoint of their function in plant growth.

Soluble Salt Content of Soils in Relation to Yield of Crops.

It is further contended, from data presented in Bulletin 22, that there is no apparent relation between the yield of crops and the soluble salt content of soils and the statement is quite true when thus based. But it should be generally understood that were the converse of this contention very strongly marked such data as are collected and presented in Bulletin 22 must be expected to fail utterly to reveal the fact. These are the facts regarding the data used: (1) Assumed, not measured, yields of crops form the basis of comparison; (2) single and isolated soil samples for determination are taken to reveal field conditions, which they seldom do closely; (3) much of the chemical work was done outside the laboratory under conditions prohibitive of the necessary accuracy; (4) duplicate solutions prepared from the same sample of soil are recorded as differing by as much as 6.38 and 12.34 parts per million for PO_4; 3.15 and 23.39 for NO_3; 9.43 and 15.33 for K. It would be strange indeed if, under such conditions, anything but a medley of results were secured.

But the results of a whole season of much more critical and reliable work along these lines which preceded the gathering of the data in Bulletin 22 and a second year's work following this, still more critical and exhaustive, are left out of consideration wholly in reaching the conclusion under discussion. The first year's work referred to pointed strongly to the conclusion that, where other conditions of growth are equally favorable, the largest yields of crops are not only associated with the soils yielding the largest amount of water-soluble salts, but that the sap of crops growing on such soils is also richer in the same salts. In other words, it had been shown that on soils from which the largest amounts of water-soluble salts could be recovered more of the same salts were carried in the sap of the plants growing upon these soils, and the data may be found in Bulletin No. 26 of the Bureau of Soils, in which the letter of transmittal acknowledges the accuracy of the data but rejects the conclusions drawn therefrom.

The second year's work, whose results are throughout in accord with those of the first year, show the following relation between yields and the water-soluble salts which had been recovered from eight soil types upon which two crops were grown to maturity under normal field conditions and where the yields were accurately determined by weighing. The soil types used were selected with a view to having those of different productive capacity, and four of those were rather above, and the other four rather below, the average of good soils. Taking the yields and the water-soluble salts recovered from the poorer soils as 100, the relations found are as stated below:

	Four Poor Soils	Four Good Soils
N+P+K in samples once washed..	100	188.5
N+P+K in " 11 times " ..	100	193.1
Yield of shelled corn............	100	191.7
Yield of potatoes................	100	271.4

It is here clear that there is a marked increase in yield, both of corn and of potatoes, where the water-soluble salts carrying nitrogen, phosphorus and potassium are present in largest removable amounts, whether this is shown by one or by eleven washings of the same sample.

Not only was this strongly marked relation shown to exist when the soils are thus grouped, but four equal areas of each of the eight soil types were treated to 300 pounds of guano and other fours to 5, 10 and 15 tons of stable manure respectively, and the differences in recoverable water soluble salts determined throughout the season, together with the yields of corn and potatoes, with the results given below. In this table each value is a mean from 32 field plots.

	Soluble N + P + K	Yield of Corn	Yield of Potatoes
No fertilization ...	100	100	100
300 pounds guano..	103.1	110.5	117.2
5 tons manure....	106.8	120.9	131.7
10 " "	109.7	135.9	141.9
15 " "	113.5	140.0	157.4

It is thus here shown that with each increase in the amount of the three plant food elements which could be recovered from the soil there was a regular and corresponding increase in the yield of each of the two crops, the gain in the corn being almost directly proportional to the increase of the three plant food elements recovered by water from the soil. With data thus strongly indicating larger yields associated with increasing amounts of water-soluble salts recovered from the soil, collected before the data of Bulletin 22 and confirmed by a second year of still more critical work, the whole work is ignored and the reverse relation held to be demonstrated by data of the character stated.

Soluble Salt Content in Soils Constantly Maintained.

This is another of the contentions woven into the fabric of Bulletin 22 but without basis in recorded data other than that spread upon its pages in the form of analyses of some Rothamsted soils which are offered to introduce the statement "that the decreasing yield from the continuously unmanured wheat plot has not been due to a loss of water soluble material, or rather that there has been no permanent disturbance of the solution equilibrium and concentration," citing especially the bureau's analyses of soils from plots 3 and 11 of the Broadbalk field. Such data are given in evidence, utterly ignoring the detailed, full and careful data published from the Rothamsted laboratories pointing strongly to the very opposite conclusion, as may be seen from the tables, Bulletin 26, Bureau of Soils, pp. 23, 24, 80, 83. The detailed analyses of the soil solutions leaving the Rothamsted plots as drainage water show that that from the plot continuously unfertilized are not only the least concentrated of any in the whole series of 16 plots, but that the total solids in solution from this plot stand as 246.4 to 425.9 coming from plot 11, or as 100 to 173, while the relative mean yields of wheat stand as 100 to 215. Moreover, there is a remarkable and clear relation between the yields of nearly all of the plots of this series and the concentration of the drainage water leaving the respective plots, the yields generally increasing with the soluble salt content of the drainage water. Not only is this true for the total soluble salt content, but the amount of potash carried in the drainage water coming from the plots to which potash fertilizers have been continuously applied, when compared with that from those to which none has been given, stands in the ratio of 425 to 100, as an average, and there is no individual exception.

Such, in brief, is the character of the data spread out by Whitney and Cameron in Bulletin 22. Thus did they ignore pertinent, undoubted facts collected by the bureau or published elsewhere, tending to disprove their views. Such is the almost utter lack of evidence collected either by the bureau or by others which may fairly be placed in support of their main contentions, and yet no work has since been done, or at least published, which can be placed in support of these views. On the contrary, the energy of the bureau is being expended in an effort to accumulate data in support of the theory that poor and runout lands are so because of the accumulation in them of imaginary toxic substances. Bulletins 36 to 40 record their most strenuous efforts along this line.

Toxicity as a Factor in the Productive Capacity of Soils.

In Bulletins 36 and 40 are given general reviews of literature relating to this subject, and in these and No. 28 the main body of experimental data thought to support the theory that soils are rendered unproductive by poisonous excreta thrown off by the roots of higher plants. However plausible and attractive such a theory may appear, a review of the data and discussions presented will convince the unbiased student that little has yet been done which may properly be considered other than speculative contributions to the subject. As pointed out, the main contentions of the Bureau of Soils supposed to make the consideration of the toxicity factor pertinent are not supported by its own work or that of others and are not true. It has made no discovery, therefore, demanding such a factor; but while this fact should be clearly recognized, it may be well to retain the old theory in the list of alternative working hypotheses, although it must be conceded to offer less of promise than many others or than it did when originally proposed, for our present knowledge makes it quite uncalled for in explaining observed relations.

But were it true that toxic excreta do play an important rôle in rendering soils unproductive, it must be admitted that nothing yet has been published, either by the Bureau of Soils or others, to which reference is made by the bureau, which should in any sense be regarded as proof. Indeed, much of the bureau's data can hardly rank as even suggestive evidence regarding the existence of such conditions in the field; because nearly all of the work has been done with seedlings placed under extremely cramped, abnormal and unsanitary conditions, the plants fed chiefly by the small amount of nutrients stored in the seed, and the experiments terminated after a few days or at most after two or three weeks. In illustration, take the experiments with agar agar, where wheat seedlings are grown inside of glass tubes with inside diameters less than that of an ordinary lead pencil (6 to 8 mm.) and 3.3 cm. long; three such tubes placed end to end, supported on a glass rod with their ends separated 2 to 3 mm., thus forming a segmented tube to be filled with transparent agar agar, solid when cold, and standing in similar agar contained in a glass vessel, the whole system arranged to be revolved on a klinostat to neutralize the directive effect of gravity. When previously germinated wheat plants are transplanted into the agar inside one of these tubes before it has solidified, and compelled to grow with its roots thus circumscribed it is held that if toxic excreta are developed they will become so potent as to compel the roots, when they reach a gap between two segments, to turn from their course along the axis of the tube and grow outward into the fresh uncontaminated agar of the outer vessel. It is assumed that if more roots turn outward, the presence of a toxic substance is demonstrated, and further, that the toxic substance was excreted by the roots and is a normal and necessary function under field conditions.

Plants were grown in free agar in large numbers until the roots, by assumption, had charged it with toxic substances; such agar was then remelted and filtered and used to fill other tubes or to surround tubes containing fresh agar, the contention being that if the outside agar is more toxic than that inside the tube a smaller number of roots would grow outward into the poisoned agar. Just why any should grow outward into the poisoned agar is not made clear; probably it is because those particular roots had rendered the immediate contact agar more toxic than that outside! But seriously, the experiments would seem to be quite as conclusive a proof that the roots growing inside the tube, or growing in the free agar, have reduced the water content of the agar or its soluble salt content and that the roots simply turned one or the other way according as available water or soluble salts are more abundant. Our own observations have shown that plant slips placed in water containing sugar, dextrine, agar agar in the condition described by the Bureau of Soils, and even in water holding suspended clay, wilt sooner or become less turgid than check slips placed in pure water, thus indicating that water is less readily obtained under those conditions. It is certainly to be expected that when as many wheat roots grow under such cramped conditions as are here under consideration, as are reported in the bureau's experiments, there must be developed a stress for water and it seems just as rational and quite as certain that the deflection of the roots may have been due to this condition. The growing of large numbers of plants in free agar agar would certainly reduce the per cent. of water and the melting of it over would reduce it still further. As it is not said that strict quantitative measures were taken to secure absolute equality of water and salt content between the inside and outside agar, the results are subject to the same interpretation as that suggested. These ingenious experiments, therefore, can not be seriously held to demonstrate that roots excrete toxic substances, neither can it be held that even if toxic substances were developed as either normal or abnormal conditions the deflection of the roots was due to them, and there is nothing in the whole range of experimental work covered by the three bulletins in question which can be held to establish, or even necessarily suggest, a probability of toxic substances in soils which seriously affect their productivity.

The loose reasoning here referred to, and characterizing the whole of Bulletin 40 and indeed of the other two as well, appear, to the writer, so out of accord with the planning and execution of these particular experiments with agar agar, when coupled with our personal acquaintance with the one whose name appears as senior author, that we are unable to feel that either the language used or the conclusions drawn are his. This I do know: It was my great surprise and misfortune, after having submitted manuscript for publication, to find my own name on the printer's proof as joint author of Bulletin 22, maintaining views directly opposed to those we had submitted and which had been laid aside, not to be published "until after the bureau had expressed its views." This much in justice appears necessary to avoid placing criticism where it may not belong. It can never be the privilege of the head of a government bureau to subscribe the names of subordinates to views he knows they do not hold. Indeed, the interests of science, if not a sense of justice, should impel any chief to encourage in his subordinates the greatest freedom of expression of views on scientific problems of investigation and to avoid in every way indicating the supposed trend of lines of experimentation from which data are sought.

The true character of some of the more recent evidence being presented in defense of Bulletin 22, along the line of toxicity studies, can be better understood from the closing sentence in Cameron's preface to Bulletin 28, when the facts in the case are known. Cameron says:

The authors of the present paper have had a leading part in the development of the work which the bureau has been conducting along these newer lines of soil investigation, and it is believed that the description of the investigations which have made possible the production of a luxuriant lawn upon a naturally unproductive soil at Takoma Park, Maryland, as well as helped in a very large measure in the development of our present views concerning soil fertility, will mark a decided step forward in soil studies and prove suggestive to other investigators in this most important branch of applied science.

The facts regarding the investigations "*which have made possible the production of a luxuriant lawn upon a naturally unproductive soil*" in Professor Whitney's front yard in Takoma Park, as pointed out by Cameron, are these: In August, 1904, the area to be treated was dressed with stable manure at the rate of about forty tons per acre and the soil, which at the time was filled with a dense network of tree roots, many of them large, making it difficult to dig, was spaded and then seeded to lawn grass which came up and, during the fall, looked well. Cameron thought he saw the utter rout of the bureau's toxicity demon from this lawn and the transformation of a "*naturally unproductive soil*" into one of rare fertility. But the severe root pruning and the loosening of the soil incident to spading in the manure, combined with the fall rains and cool weather which gave the grass seed exceptional facilities for growth, at the same time provided excellent opportunity for the development of new and active tree roots, as was later discovered by the bureau; and early in the spring of 1905, as reported in Bulletin 40, the ground became "almost completely filled with young active growing tree roots." The plain and simple fact is, these roots so thoroughly sapped the soil of its available moisture, rendering it so hard and dry, that early in May the grass had died. Nevertheless the preface was allowed to stand.

The new roots in the lawn soil were discovered and the thought at once arose "*that these might exercise some malignant effect upon the growth of grass.*" Five full tablespoons of soil each were effectually paraffined into the standard wire baskets; in these were carefully transplanted young trees of pine, maple, tulip, dogwood and cherry, two baskets being reserved without trees as checks. This done, equal numbers of germinated wheat seedlings were set out about the trees in the baskets and allowed to grow two to three weeks, replanting as the stress became too severe, until at the end of the season 81 trials had been made under such rigid laboratory control—and with the remarkable result that in all but 10 of the 81 trials the green weight of the wheat trials was less where the wheat grew under the trees! Moreover, the bureau wisely observes, this reduced yield occurred in spite of the fact that the roots of the several wheat crops were left in the soil, which must have acted as green manure and thus tended to counteract the deleterious effect of the tree roots on the wheat (p. 19, Bull. 40). Then again, and with characteristic logic, the better growth of wheat under the trees in the last three crops is ascribed to the trees passing into the condition of winter rest.

It is thus the pages run on and one bulletin follows another, all having the same indecisive and misleading character; all clearly bearing the stamp of two minds, although different authors may be assigned on title pages. If the bureau really has faith in its utterances, why will it not rise to the stature of serious work and get out upon some field with appliances which will enable it to extract from one or more of its highly unproductive soils the toxic substances about which it has written so much and yet in reality accomplished almost nothing? This the farmers of the country have a right to demand, or else that it shall turn at once its energies into channels which have more of promise.

SINCE writing the above there has been issued from the bureau (November 6) another bulletin, No. 47, along the same line, under the title "Certain Organic Constituents of Soils in Relation to Soil Fertility" which, not to be misleading, and to be true to the subject-matter presented as well as to the facts as known with which the bulletin deals, should read *Certain Organic Constituents in Plants in a Possible Relation to Soil Fertility;* for although it is stated (p. 9) that "The toxic properties of soils have been demonstrated and the existence of toxic bodies is a reality with which it is necessary to deal in future soil studies on the fertility and infertility of our agricultural lands," and further along it says (p. 12): "It has been demonstrated by the studies described in this bulletin that substances commonly used as fertilizers in agricultural practise have in addition to their function as plant nutrients a well-defined power to overcome and actually destroy toxic bodies," yet the facts are nothing which the bureau has yet published can be considered strictly as *demonstrating* either of these propositions even under the strained and highly abnormal conditions of the experiment cited, not to say what does occur under normal field conditions.

In these experiments, as heretofore, ten wheat seedlings are grown but six to thirteen days in solutions contained in 250-c.c. salt bottles, depending for nourishment upon materials stored in the seed, while the chief criteria for differences in growth have been the very misleading and indecisive quantities of transpiration or of green weights, whereas, in such experiments as these, it is perfectly feasible to determine precisely the increase in dry weight, both in tops and roots, and thus obtain quantities which can not be misleading, as those used are known to be, and so acknowledged at page 15 of the bulletin. Moreover, in each of the experiments cited with tyrosine, choline, piperidine, quinone, vanillin, cumarin, cinnamic acid, esculin and heliotropine it is quite as rational to assume as another, among several alternative hypotheses, that the real effect of these substances, instead of being in any sense toxic to the wheat plants, has been to simply diminish the rate at which the stored nourishment in the seed was rendered soluble and available to the growing seedlings. Indeed, the coating of the roots in several of the cases, as cited in the bulletin, suggests that the substance of the kernels may have been markedly affected in such a way as to have retarded its transformation into available plant food, and the failure of the roots to develop into the solution may quite as well have been due to a lack of dissemination of plant food, so that there was little to stimulate root development in those cases, for it is a fact well established by observation in the field that the roots of crops develop most strongly into portions of the soil where nutriments are most abundant and available. It would clearly be a waste of energy and of food materials for a plant to develop its roots into a non-nutritive solution and these experiments were never continued long enough to have developed a stress for water. It is worthy of note in this connection that often there was associated with the substances used a relatively less root development than of top if we may judge by the appearances of the illustrations, supplemented by definite statements to this effect in the text. It is greatly to be regretted that where so much pains has been taken to accumulate data and where the dry weights of the roots and of the tops could with ease and exactness have been determined, it was not done, as the extra time, expense and labor are not worth considering in view of the increased value of the data which would have resulted. We speak advisedly on this point because we have done a large amount of work along the lines of transpiration and green weights in plants in relation to the dry matter produced, the observations covering the full life of the crop, coming to complete and normal fruitage.

In the case where wheat seedlings were grown a second time in the same supposedly toxic solutions a better growth would be expected if these substances had the effect of simply rendering the nutrients of the kernels less readily transformed into available food, and it is quite possible that crushed wheat kernels placed in these solutions, thus eliminating the vital activities of seedlings, might have affected them as favorably as did the growth of the first crop and might have caused a disappearance or a reduction in the amount of the toxic substance. These experiments, therefore, can not be considered fully demonstrative. For the same reason, and because transpiration is not a measure of growth, the experiments with nitrates and with lime are also inconclusive.

But granting that the data of Bulletin 47 do demonstrate that the substances experimented with are truly toxic to wheat seedlings under the highly cramped and abnormal conditions of the experiment, it will be conceded quite rash to affirm that these substances in like quantities would be found similarly toxic in the soil under field conditions until it were known, not only that such substances do exist in the field soils, but also that they are more abundant in those which are unproductive.

The unwarranted publication of such positive conclusions as those quoted becomes still more evident when an effort is made to give quantitative expression to the recorded data of Bulletin 47 in terms of field conditions correlated with other contentions of the Bureau of Soils. It is maintained by the bureau, but without sufficient evidence, that the capillary movement of soil moisture under crop conditions is of negligible magnitude and that for this reason the roots of crops, in order to secure moisture and plant food and also in order to place the active absorbing root tips into fresh soil not poisoned by their own excreta, are compelled to constantly advance into previously unoccupied soil, and they are known to spread throughout a depth exceeding three to four feet in the case of most crops. The toxic substances of unproductive soils must, therefore, be deeply distributed throughout the root zone and to a depth of at least four feet. But the strongest solution used in the experiments of Bulletin 47, of 1,000 parts per million, means not less than 2,800 pounds per acre of field where the water content of the soil is 20 per cent. and it would mean 700 pounds per acre for the surface foot alone. In the case of 100 parts per million the amounts would be 70 pounds and 280 pounds per acre for depths of one and four feet, respectively. In the light of failures up to the present time to isolate these toxic substances from soils it will hardly be seriously contended that any such large amounts of toxic substances do exist in unproductive soils. But the smaller amounts experimented with, as recorded in Bulletin 47, either had little or no effect or they produced positive increases in growth. If, therefore, the data of the bureau along this line of toxic substances are to be given serious consideration at all, Bulletin 47 must be regarded as suggesting that on account of the probably small amounts of these toxic substances present in soils, and on account of their observed small, or else stimulative, effect when present in such quantities, toxic substances are either negligible factors in soil fertility or else they are beneficial to crops.

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SPECIAL ARTICLES

A NEW APPARATUS FOR MEASURING ELECTROLYTIC RESISTANCE[1]

The measurement of electrolytic resistance differs from that of a metallic conductor in several respects. The most evident difference is that the electrolyte has no definite shape or size. Cells of various forms have been devised to hold the solution while it is being measured and I would hardly venture to add another to the list were it not for the fact that the

[1] Paper read before Section B of the American Association for the Advancement of Science and the American Physical Society in joint session, Chicago, December 31, 1907.