A CONTRIBUTION to a SOIL SURVEY of SYRIA

for the DEGREE of MASTER OF ARTS

BY

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The books and pamphlets consulted for the preparation of this essay are as follows : -

Soil Fertility and Permanent Agriculture By Cyril G. Hopkins .

Encyclopeadia Britanica .

New International Encyclopeadia 1903 edition.

Practical Agricultural Chemistry By Auld and Ker.

Agricultural Chemical Analysis By Percy F. Frankland.

Several numbers of the U.S.A. Farmer's Bulletin and U.S.A. Agricultural Department Year Books.

Few numbers of University of Illinois Bulletins.

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SECTION I.

The Aim and Purpose of such a Survey .....

The purpose of soil surveys have always been to acertain the variety and extent of the chief characteristic soils of the country under survey, to determine the crops which can be raised to the best advantage upon the different soil types and to discover the peculiarity of each soil type as to its management and the securing of the maximum results. Another chief purpose of soil surverys is to aid the farmer in choosing his farm in the regions unknown to him. Thus the many vast resources of a country are explored by a steady and devoted work in soil surveying, and put to agricultural purposes whichif wisely and deligently practiced will annually increase the seemingly limited soil resources. It emphasises the study of large problems as yet unsolved and still in the form of theories. The present thesis does not aim at, all the above objects for its writer has had very limited experience even in the district which he has experimented upon. Soil surveys cannot successfully be accomplished by one person and in a short time but need men suited to its different departments. So the aim of this essay will be to present in as concise a manner as possible the principles involved in a progessive method of farming, use of land in general, and a brief survey of the Beirut Plain, which may serve as a start for similar studies upon the soils of Syria by other contributors.

It is a well-known fact that this part of the world is not fit for industry in the largest sense of the word, as it does not possess the natural resources of energy and fuel, but that it depends for it s subsistence mostly upon agricultural developement. The Syrian land is fairly rich and fertile and will not depleted, in most parts, of the plant nutriments for a long time. But still the maintaining of permanent fertility of the soil should be adopted as far as the future is concerned if Syria desires to run abreast of the other countries of the world and be self-sustaining. Up to the present moment no definite system of farming has been followed in any part of Syria due to a lack of knowledge of the soil and other principles involved in agriculture. The rule-of-thumb method of farming cannot survive. A full knowledge of the soil, its constituents, composition, nutritive value and an economic and time-saving method of maintaining its fertility is needed. All this responsibility falls upon the farmers and the immediate landowners, to keep up the import of their farms, (in terms of manure and fertilizers), equal to the exports (to what they give out or sell in their crops in terms of nitrogen, phosphorus and potassium). For example a big item on their import list, nitrogen, can be replaced most economically and wisely by crop-rotation system with repeated cultivation of leguminous plants and occasional turning unders etc which is briefly discussed in the following pages.

The real farmer must handle his own soil and determine its value, and remedy any existing defects in it. He cannot direct and run a farm from an office if he expects to raise rich and profitable crops, and make the most of his land without subsequent losses, Neither can the farms be managed from a state central office. The landowners of Syria must think of their own lands themselves and apply the modern methods of farming and its management.

Though the present thesis does not claim to give all the data necessary for scientific agriculture, and what might be required of a more extensive soil survey, nevertheless the writer does aspire to show how a better knowledge of the soil would be of much use to the Syrian farmer.

As to the plan that will be followed, I had better make mention at the outset. This first part treats of different kinds of soils, their qualities, their mechanical and chemical composition. A special chapter has been devoted to the principle foods from soils in connection with plant growth.

Chapter 1.

Kinds of Soils and their Qualities in general

As to the geographical distribution of soils in connection with the mechanical forces of nature, soils are divided into two main divisions, soils which are residual or sedimentary, and soils which have been transported from their place of origin.

As the term indicates, residual soils are those soils that are formed in places of their first disintegration from rocks. They are never of the same constitution as at the start, that is, as the rocks from which they have disintegrated, for they retain only their insoluable ingredients while the soluble portion is leached out continuously as disintegration goes on. Thus a limestone containing eighty per cent of calcium carbonate and twenty per cent of impurities mainly silicates and iron, may weather to a soil composed entirely of impurities from which the calcium carbonate has been completely removed by leaching.

With this class may be grouped the humus or peaty soils due to accumulations of organic matter in bogs swamps and marshes. IT must be understood that the term humus is not synonymous with organic matter. Humus includes only that part of the organic matter that has passed the most active stage of decomposition and completely lost the physical structure of the materials from which it is made, and thus has become incorporated with the soil mass.

Transported soils are the disintegration product of rocks which by various natural carrying agencies as wind, water and glaciers have been transported and retransported from the place previously occupied by the rock and deposited in places which they now occupy. Glacially transportedsoils, sometimes hundred or more feet thick, are characterized by the presence of worn or rounded stones varying in size from sand grains to bowlders embedded in silty clay. Many of the glacial deposits are covered several inches by lowss deposits which are transported soils by wind action and characterized by absence of pebbles and presence of a large proportion of silt with some very fine sand and little clay. Loess deposits occur in high elevations where wind action is at its best and where all the soil material carried may precipitate. There are evidences of such a type of soil, loess, being transported by water too. Alluvial soils, often of very mixed origin and fertile, are the common soil deposits in river valleys and other lowlands washed from the higher lands.

Other types of soils which may fall under any of the above classifications are ash soils or the accumulations of ashes ejected by volcanoes which are often of considerable extent and frequently very fertile. The productive regions around Vesuvious are soils of this type. There is another kind of soil of volcanic origin, of frequent occurence, derived from disintegrated volcanic lava.

Soil materials consist of stones, gravel, sand, silt, clay and organic matter. Clay has a plastic and sticky property, probably in the molecular state of division and without granular character. It is chiefly composed of plastic substances as hydrated aluminum silicate and often of, more or less, undecomposed or partially decomposed mineral particles. Silt is granular as seen through the microscope, but its particles are smaller than sand and if free from clay i is not plastic.

Different types of soils depend upon the relative proportion of these several soil materials, easily determined by mechanical inspection. The following general groups of soils are recognized.

General Grouping of Soils

Group Names	Description
Peat soil	With 25 to 75 per cent or more of organic matter.
Peaty muck	10-25 per cent of organic matter with loam.
Muck	10-25 per cent of organic matter with much clay.
Clay	plastic predominating.
Clay loam	Much clay with loam.
Silt loam	Much silt with loam.
Loam	Sand, silt, clay, and organic matter with neither markedly predominating.
Sandy loam	much sand with loam.
Sand	Sand without much silt or clay.
Gravely loam	Gravel with loam.
Gravel	Gravel without much silt or clay.
Stony loam	Stones with leam.
Rock outcrop	Disintegrating rock.

Table taken from Soil Fertility and Permenent Agriculture By Cyril G. Hopkins.

The good or bad qualities of a soil depend upon the requirements of the crops which are to be grown upon it. Some crops require more of one plant food element than others, while others are wholy or partially indifferent to the presence of some of the elements for example legume plants requier and flourish better on a limy soil [illegible] otherwise without caring for nitrogen, cotton, potatoes and several other crops prosper better uponthe soils exceptionally rech in potssium. It is only after a consideration of the requirements of plants that a clear conception can be formed of what characters the soil must possess for it to be a suitable medium on which profitable crops can be raised.

In the first place the soil to be of aby use must be sufficiently porous and loose to allow the free growth and extention of plant roots. To attain this quality the soil must be tilled and well pulverised which effort is crowned with success in most cases except in those soils which are so compact and of such a texture that one seeping of water will harden it to such an extent as to stop and completely check the normal developement of plant roots. On the other hand soils must not be so loose as to allow plants to be uprooted by wind and themselves suffer transportation. In such soils plant roots cannot get a good grip of the soil and evaporation is liable to increase to a high degree.

Plant root cells like cells of the other parts of the plant need a constant and fresh supply of oxygen to carry on their normal function and to get rid of their waste products hence the necessity for the continuous circulation of fresh air through the soil, or aeration. Thus if the soil is too compact the pores will be clogged with either carbon dioxide, water, or both and roots die of suffocation just as would an animal die under the same conditions. Water-holding capacity of soils is very important as plants need considerable amount of water for their nutrition and growth. If , on the other side, a soil allows too much free drainage drought sets in and plants, not getting enough water for their needs, become stunted in size. The conclusion is that too much water is bad and too little is equally injurious. The temperature of the soil is very important especially in the first days of germination. The soils upon the north side of the mountains are usually lower in temperature than the south side soils, and soils of high water content suffer the same condition. Black soils are warmer than the other typesof soils. The last two and very important qualities of soils are that they ought to be deep enough to allow extensive root developement and easy to work with implements that is they ought no to be imbedded with too many big stones and bowlders.

With all the above conditions suitably fulfilled the soil may still be barren if plant food in it is missing. Soils usually contain the plant food too, but in different quantities which may be in abundance or need to be replenished and increased as the case may be by addition of soil fertilizers and manures, as we shall notice in the following chapters.

Chapter 2.

The Principle Food from Soil in connection with Plant Growth.

As the classification of soils which familiarized us with the physical and mechanical properties of soils though an important factor, did not carry us far in our knowledge of soil and the differentiation of the relative value of the several types and groups of soil, from an agricultural point of view, we need to go into a short discussion of the comparison of plant food in air and in soil, and into a consideration of the part the latter plays as regards its constituent

The food that plants take from air is replaced spontaneously and no human time and thought is spent over it, for the carbon dioxide, one of the essential plant foods, by the action of the wind and the law of gas difusion and the phenomenon of the carbon cycle is uniformly present everywhere. Plants can never exhaust it even though it constitutes such an insignificant percentage of the atmosphere (about 0.04%), while the greatest bulk of their woody constituent is made of carbon. The following example will demonstrate the favorableness of a gaseous medium for plant nutrition.

The carbon present in 10,000 pounds of air is a little over one pound and over an acre of land less than 10,000 pounds. While in a single crop of 100 bushels of this acre, amounting to about 5600 pounds, it is about 2500 pounds. Thus four such crops would exhaust all the carbon from air and two such crops if the stalks be taken into consideration. But still we see that the atmosphere has never been depleted as regards its carbon. But if we consider that three fourth of the atmosphere lies over the oceans and the fact that only one fourth of the land is cropped and that twenty five bushels is anaverage crop be taken into account then the supply of carbon is suffisient not for two years only but for 128 years, disregarding the above mentioned laws which govern its even distribution and restoration. (from Soil fertility and Permanent Agriculture By Cyril G. Hopkins).

But this kind of a ready supply of nurishment for plants is true only in the case of the atmosphere which is a gas. These phenomena do not play the same part when it comes to the soil. Seldom two soils will be found to have the same amount of nitrogen, phosphorus, and potassium and if they do the extent of their availability would never coincide.

Thus we see that land, including water, requires all attention as regards agriculture while the atmosphere will so the rest and do it well. It is these facts which impress and emphasise the need of science in agriculture, and the fairest approach to such a knowledge of soil would be the study of its constituents, their respective nutritive value and different proportions of each in ordinary soil as well as in abnormal one.

The three recognised elements, in the soil, namely nitrogen, phosphorus, potassium are firet and first and foremost in value as regards plant nutrition of which fairly large fractions are returned to the soils by the stalks of the crops if they are left on the farm after harvest.

Nitrogen is not a constituent of the mineral matter of the soil and existsonly in the organic matter found in the earth. It is indispensible in plant growth and no phenomena of life can exist without it, and it is the organic matter, vegetable matter or humus, of the top soil from the decomposition products of which nitrogen is furnished, to most growing crops, by a process known as nitrification which we shall mention more fully as we proceed. Even with the enormous amount of free nitrogen present in the atmosphere still plants can have no access to it directly. Only one family of plants, indirectly, through the agency of certain kinds of bacteria, attached to their roots, utilises the atmospheric nitrogen in available form. If the nitrogen of the air was available to plants it would furnish crops for 500,000 years, 100 bushels per acre, before it could be exhausted, overlooking its return to the atmosphere. Carbon has no commercial value as fertilizer though existing in traces in the atmosphere while nitrogen, with its abundance in air, in available form is worth money in return. The nitrogen of the air can wisely, by a farmer, through the orderly and systematic method of crop-rotation be returned to the soil and the expenditure for restoring nitrogen to the soil by commercial fertilizers be saved. It being removed from soil, in seeds especially, must be restored to the soil in one way or another to maintain its normal fertility. Seldom we find natural resources of nitrogen which can be relied upon. Only few nitrate deposits have been found such as in Chile and Peru whey strech in extensive deposits thought to have resulted from the decomposition of sea-weeds. These deposits have not only a local blessing to agriculture but have been exported for and wide all over the world. If the 45 million tons removed from these deposits had been applied for fertilizing purposes very few barren lands would today be threatened with permanent destruction, but unfortunately most of it has been employed in manufacturing explosives. Of all plant foods nitrogen has received the most attention and considerationand its supply has been maintained in many localities b y plowing under farm manures and green manures as clover or cowpeas. Soils differ much in nitrogen content the highest known is 35,000 pounds of nitrogen in 2,000,000 pounds of surface soil which is taken to be6 2/3 inches deep per acre. The lowest may be under 1000 pounds in the same amount of soil. The well-balanced land in nitrogen content will be a range between 8,000 pounds and over, and 3,000 and over is a fair average. In general the nitrogen content of a soil can be judged by the degree of its dark color, for the darker the color, the richer the soil is in organic matter and hence in nitrogen. An insignificant amount of nitrogen, in the form of its compound, reaches the soil through rain.

The next element in importance to plant growth is phosphorus. Like nitrogen it is closely associated with all living cells constituting the largest proportion of theirnucleuii. The only source of phosphorus for plants is what reaches them through the soil. It is a constituent of the mineral part of the soil as well as of the organic matter. The phosphorus in the soil occurs usually in an insoluble form and it is by the action of acids in the soil that they are transformed to an available form. It is for this reason that whatever we restore to the soil in the form of phosphates we should first gring to increase the chance of their equal distribution and to render them soluble by acid treatment, so as to make them more available. Phosphosrus is removed mainly in the seeds and specially in the germs of the seeds,which are likely to sold away. What is left on the field, as the stalks and roots, retain very little of the phosphorus the plant extracted from the soil. And there being no natural way of restoring phosphorus, as by the method of crop-rotation and legume plants, the only way left is by artificial means. The recovery is indispensible, for soils contain amounts of phosphorus and its diminution is sure to bring about poorer crops. It is altogather a wrong idea that live-stock enrich the soil they pasture upon, in phosphorus and nitrogen found intheir excrements for they part of the nitrogen in their bones muscles and milk. Simple subtraction shows us that they actually impoverish the soil they pasture and live upon. Then there is no room left for the farmer in replenishing his soil with phosphorusexcept the application of the different kind of natural phophates or farm manures and bones. The rate at which it must be restored may be judged form the amount taken by seeds. In 1,000 pounds of corn there are about 100 pounds of germ containing more than two pounds of the element phosphorus. An acre of corn will therefore remove about 12 pounds of phosphorus in the hundred bushels it may yield. Wheat crops remove more.

The percentage of phosphorus in the soil is small when compared with the requirements of plants especially when we also consider how it is concentrated in the farm products sold, as milk, seeds, flesh and bone. The bones of animals consists largely of tricalcium phosphate which when pure consist of about 20 per cent of phosphorus, but not being purely tricalcium phosphate its phosphorus content is lowered to about 10 per cent.

Phosphorus is easily made available by different soil stimulents as land plaster etc which is not suitable at all and its use should always be avoided. If tricalcium phosphate be treated with pure water and filtered the solution will show no test for phosphorus while a small quantity of land plaster or salt will cause it todissolve in appreciable amounts. This stimulent application or rather depletion process is most injurious to land for it calls for the reserve plant foods and by the by a stage is reached that even heavy application of such stimulents fail to liberate sufficient phosphorus or other plant foods for profitable crops. Soils differ in phosphorus content from one another, the highest is 15,000 pounds in 2,000,000 pounds of soil, thelowest 160 pounds,a well balanced soil would be between 1,000 to 2,000 and upwards.

It one of the blessings of nature that she has furnished the farmer with rocks rich and high in phosphorus, by which he can correct the fertility of his soil and replenish as soon and as much as phosphorus is removed from his soil. These rocks occur in many localities and are not restricted to a place or two like the nitrates, and as they have no explosive properties, in the state found in nature, have been exclusively reserved for agricultural purposes.

The five elements, potassium, magnesium, calcium, iron and sulphur are contained in most normal soils in such large amounts, compared to the requirements of crops that the supply rarely becomes depleted. Thus in most cases the depletion problem is narrowed down to nitrogen and phosphorus and lately to potassium too.

Potassium, of late, has come to be recognised as an important commercial fertilizer. It is required in considerable amounts in plant growth and constitutes a great portion of the cell. The ashes contain a great part of the potassium. unlike phosphorus it is found more in the stalks than in the seeds, and it is this element which gives body and rigidity to the plant and not silicon as is commonly supposed. The plant practically takes up no silicon from the soil for this purpose. Potassium though constituting the largestportion of most embryonic tissue has not yet been proved to be an essential part of protoplasm and has been given the same place as calcium, as a plant food.In addition to above another function ascribed to potassium is that it is a carrier of nitrogen and phosphorus, and leads in the process until fixation of carbon is finished by photosynthesis. It is definitely proved that the organic acids developed in plant unite with the nitrates phosphates and potassium salts which the plant draws up. The tartarates in grapes, and oxalates in sorrel are typical examples of the above process. It is also supposed that it has great influence in the formation of carbohydrates in plants but has not been varified and the information is as yet insufficient to determine whether this influence is direct or indirect. Most of the potassium of the soil is lost by the process of leaching as can be very distinctly proven by analysis of of soil drainages. Peaty soils are almost completely depleted of their potassium by the same process. For average crops the supply of potassium in most soils meets the need of the crops. Of late it has attained much importance as fertilizer for several important crops for average soils do not seem to be able to meet their requirement as for as potassium is concerned.

The most important known sources of potassium salts had been by kindness of heaven, granted to Germany, but of late there have been revealed other vaster sources in Alsace and Lorain which put an end to German control over potassium.

As to the amount of potassium found in soil the average and well balanced would be 35,000 pounds in 2,000,000 pounds of soil, the lowest being 3,000 and the highest being 60,000 pounds in the same amount of soil.

In connection with plant food in soil as mentioned above there are several other elements which are absolutely necessary to the normal growth and developement of all agricultural plants and in their order of importance are iron, magnesium, calcium, sulphur. We need not bother ourselves about these elements as soils practically have never been found depleted from them except calcium, but still mentioning some of their functions will add to our store of knowledge about soil.

Iron as compared with crop requirement is abundantly found in all soils. It has a very important connection, directly or indirectly with the formation of chlorophyll though analysis does not show its presence in chlorophyll. If iron is withheld from a plant, the leaves will not become green and when it is applied they turn green. We can safely regard the action of iron as an indirect one and totally discadd the common assumption that the green color of plants is due to the presence of iron compounds of that color, as incorrect. The fact that dilute acids do not dissolve the iron in nuclein compounds indicates that iron is not found as a primary compound floating around in the chlorophyll but that it is a constituent of the living matter of plants. It is an interesting fact that the need of phosphorus and iron, to crops, and their supply in the soil are inversely proportional. Phosphorus in crops is forty times as much as iron while iron in soil is forty times as much as phosphorus and if the phosphorus be depleted in 100 crops it would take iron 160,000 years to reach a point of depletion.

The place of calcium and magnesium cannot be so easily determined. As plant food elements they can be given a far removed second place giving nitrogen and phosphorus first place. The function of magnesium as plant food is very similar to that of potassium and is stored in seeds in relative abundance. Like potassium it is an essential constituent of protoplasm and the theories of potassium function apply to it as well.

Calcium does not seem to be so badly needed by many plants in large amounts as the previously mentioned elements, though in small amounts it is of vital importance to all plants. Its usefulness as far as the legume plants are concerned is very marked. It is very seldom exhausted despite the loss suffered by leaching, in the form of calcium calcium carbonate. Its application tosoil is usually for acidity correction cases and for legume plants. Acid soils contain sufficient calcium for plant nutrition. It is a commonly known fact that olive trees prosper better when their roots rest upon limestone rocks which fact clearlydenotes that the function of calcium in soil is to correct or weaken vegetable acids which other-the plant. Lime has been much applied as stimulent and many tracts of land have consequently become poorer due to its destructive process, produced by its caustic property, over humus and thus liberating and reducing the stock of plant food stored in the soil.

The legume plants' tendency to calcium exposes the fact that nitrification does not proceed in acid mediums and is encouraged in alkaline ones. It is applied only in two cases, one for encouraging nitrification of legume plants and the other under the condition when soils contain large amounts of phosphorus and potassium which are too slowly available for profitable crop production in which case it hastens the liberation of these mineral elements.

Sulphur is taken up by plants in the form of sulfates for the formation of their proteins and is an essential element for normal growth and developement of all plants. It is liberally present in the soil and is brought back to the soil by rain, in quantities more than sufficient for crop requirement, after it has been carried into the air in connection with the products of combustion and of decay. Similar amounts of nitrogen are brought back to the soil but as compared to crop requirement it is very insignificant. Some of th e plants take more sulphur than others as onions and garlic the oils of which are chiefly allyl sulfid (C_3H_5)$_2$S. In the elementary condition sulphur in soil, though seldom found as such has an indirect connection, to plants, of protecting against insects and fungus growths and for this reason has been employed as insecticide and fungicide to plants, most in danger of attack and, unable to resist such outside foes.

Other elements in soil as sodium, chlorine, manganese, aluminum, and silicon are taken up by plants in extremely small quantities though notessential to normal growth and developement of plants.

Common functions may be performed by elements of the same family as potassium and sodium both being alkali metals, but for some reason or other plants prefer one to the other, and sodium has been proved to be altogather a non-essential element to plant growth. Manganese, magnesium, or iron might serve just as well in correcting soil acidity but cannot take the place of calcium for reasons not yet proposed and verified.

The plant food liberated from an average soil during an average season with average farming, roughly estimated, is equivalentto about 2 per cent of the nitrogen, 1 per cent of phosphorus and 0.25 percent of the potassium contained in the surface stratum or 2,000,000 pounds of soil. The soil loses part of the plant food it contains by leaching afer soution in rain water or soil water, as mentioned before, which fact is of very great consequence for every year large amounts of nitrogen may be lost. Potassium, calcium and magnesium suffer leaching most. To avoid loss by leaching it is stated that rotation of crops should be so arranged so as to absorb as much of the plant food as is made available. Other ways by which land may lose a part of its plant food to very limited extent is by mechanical erosion as surface washing by rain and wind action, and voltilization chiefly of nitrogen in the form of ammonia.

Chapter 3.

Mechanical Composition of Soil.

The discussion of this topic is very closely related to the chapter devoted to "the kinds of soil and their qualities in general" so we shall not dwell much upon the subject except ...

to avoid all repetition, of the mechanical analysis and to add what may havebeen left unsaid in the above mentioned chapter.

Mechanical analysis of soil consists of separating the particles of asoil into six grades of fineness which determine its composition including jumus, water and soluble matter as well. The grades range between stones and clay, the intermediate steps being gravel, sand, fine sand, silt and fine silt. The productivity of the soil depends much upon the different proportions of these grades which determine the texture, structure, size of paricles and arrangement of the soil. None of the above four or five constituents are in themselves of value for growth of crops if by their mixtures they do not correct each others deficiencies. The extent of water circulation, retention of plant food, aeration, temperature and plant root growth are all dependent upon the above qualifications. A perfect soil would contain, suffieient sand to render it pervious to fresh air and prevent water-logging, and sufficient clay and humus to preventdrought and the required amount of plant food and absence of acidity. Clay humus and silt have had their proper share in the previous pages and what is left untouched is sand. Sand consists of quartz or flint and the individual particles can easily be seen with naked eye or readily felt as gritty grains between the finger and the thumb. If sand is chemically pure it consists of silicon dioxide (SiO_2), or quartz a clear transparent glass-like mineral. But seldom do we come across it in such form and ordinarily we meet it in an impure form generally colored by iron dioxide. It has very little retaining power for water and would be liable to become very hot in the daytime and cool at night.

The generally recognised size of some of the different grades of the soil are as follows :- Coarse sand .1-.2 mm,. Fine silt .2-.04 mm., Silt .04-.01 mm., Fine silt .01-.004 mm,, Clay below .004 mm..

The discussion of water, as a mechanical constituent and an all important supply to growing crops, may well fall under the topic of this chapter.

The plant roots take up their food from soil in exceedingly dilute water solutions as is shown by the following determination :- that one ton of dry matter of a crop absorbes and utilizes from 300 to 500 tons of water, at the same time considering and excluding carbon which is taken from air directly. This fact shows the importance of a liberal supply of water in agriculture, because during the life of a plant there is a steady sbsorption of water by root hairs and evaporation through the stomata of the leaves. The la tterppocess is termed transpiration. An acre of cabbage is known to absorb and transpire more than ten tons of water per day when the weather is fine. No liberal application of manure will correct water shortage and deficient rainfall and plants will remain stunted and their yield seriously reduced. The most satisfactory amount of water present should not be more than 40 to 60 per cent of what would saturate the soil, under which condition every particles of soil is coated with a film of water affording sufficient space for aeration and removing water-logging danger. When this film becomes very thin plants tend to become unable to absorb all the water present in the soil.

Water is supplied to the surface soil from the subsoil by capillarity. In order to decrease the danger of losing much water by evaporationwe may discourage capillarity be enlargening the pores of the surface soil by careful tilling and harrowing. This process if well managed can save water in lands with deficient supply of water, and enables the farmerto cultivate it every alternate year. On the other hand if too little capillarity is going on it may be incouraged and promoted by decreasing the size of the pores byrolling the land.

The following scheme is most appropriate for most mechanical constituent determinations.

Scheme for the Mechanical Analysis of Soil.
(from Practical Agricultural Chemistry by Auld and Ker.)

Air-dried soil
Weigh out one pound of the air-dried soil. Work in mortar with wooden pestle until not more passes through the 3 mm. sieve.

- **Residue** wash free from earth dry and weigh this fraction consists of. — **STONES and GRAVEL**
- **Portion passing through the Sieve.** This is the "air-dry" fine earth. Treat 10 grams with 100 Cc. of N/5 HCl. Allow to stand one hour, with occaisional stirring. Filter and wash free from acid. Dry and weigh.
  - **filtrate** contains the dissolved matter The loss suffered by the soil during treatment represents. — **SOLUble MATTER and HYGROSCOPIC MOISTURE**
  - **Residue** Wash the residue with ammonia water on to a small sieve (100 meshes per linear inch), Collect the liquid in a beaker marked on the side at 10 cm., 8.5 cm., and 7.5 cm., from the bottom.
    - **Residue separate by means of the 1 mm. sieve.**
      - **Residue** dry and weigh consists of — **FINE GRAVEL**
      - **Portion passing through sieve** dry and weigh consists of — **COARSE SAND**
    - **Muddy liquid** Make up to the 8.5 cm. mark with ammonia water. Allow to stand for 24 hours, and pour off the liquid. Repeat until the washings are clear.
      - **Residue** make up to 7.5 mark with ammonia water. Allow to stand 12 1/2 minutes, and pour off the liquid. Repeat until washing are clear.
        - **Residue** Make up to 10 cm. mark with ammonia water, and allow to settle for 100 seconds. Repear until washings clear.
          - **Residue** Wash into porcelain dish. Dry, ignite, and weigh fraction is — **FINE SAND**
          - **Washings** Evaporate to dryness, ignite and weigh. Fraction is — **SILT**
        - **Washings** evaporate to dryness ignite and weigh fraction is — **FINE SILT**
      - **Washings** evaporate to dryness ignite and weigh fraction is — **CLAY**

Chapter 4.

Chemical compositinn and organic agents bringing about chemical changes in the soil in general.

Soils contain most of the elements found in silicate rocks, but in varying proportions, and ordinarily organic matter as well. The following table prepared by Kilgard will show the average chemical composition of soils of humid and arid regions.

Average chemical composition of soils of Humid and arid regions.
(from New Internatinnal Encyclopaedia volXV 1903 edition)

Constituent	Humid region (average of 466 soils)	Arid region (average of 313 soils)
Insoluble matter Soluble matter	84.031 4.212 } 87.687	70.565 7.266 } 76.135
Potash	0.216	0.729
Soda	0.091	0.264
Lime	0.108	1.362
Magnesia	0.225	1.411
Iron oxid	3.131	5.752
Alumina	4.296	7.888
Phosphoric acid	0.113	0.117
Sulphuric acid	0.052	0.041
Carbonic acid	-----	1.316
Water and organic matter	3.644	4.945
TOTAL PERCENTAGE	99.563	99.920
Humus	2.700	0.750
Nitrogen in Humus	5.450	15.870
Nitrogen in soil	0.122	0.101

Plants for their nutritive process need certain chemical elements namely carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulphur, magnesium, calcium and iron. With the exception of carbon and a small proportion of exygen and nitrogen which they may partially derive from the air, plants take the rest of the above elements from the soil. And the relative amounts in pounds per acre of nitrogen , phosphorus (interms of phosphoric acid) potash, lime and [illegible] soil, by wheat [illegible]

(from Encyclopaedia Britanica vol 25)

Crop	Nitrogen lbs.	Phosphoric acid lbs.	Potash lbs.	Lime lbs.	Magnesia lbs.
Wheat	50	21	29	9	7
Meadow Hay	49	12	51	32	14
Turnips	110	33	149	74	9
mangels	149	53	300	43	42

About 85 per cent of the crust of the earth being silicondioxide, silicates, aluminum, sodium and oxygen have no value as plant food. This should not make us assume that the amount of plant food has been narrowed down and limited by nature. Out of the remaining 15 per cent plants get all the nurishment, except the carbon, some of the oxygen and nitrogen, which they require and more, provided the constituents of the soil in that 15 per cent be normal and well-balanced. The following table clearly exposes and offers us a clear conception of the relative abundance of essential plant-food elements based upon the continuance of their supply and upon crop requirements.

Relative "Supply and Demand" of Seven elements.
(from soil fertility and permanent agriculture by cyril)
(G. Hopkins)

Essential plant food elements	Pounds in 2 million of the average crust of the earth	Pounds in 100 bushels of corn(grain only)	Number of years' supply indicated
Phosphorus	2,200	17	130
Porassium	49,200	19	2600
Magnesium	48,000	7	7000
Calcium	68,800	1¼	55000
Iron	88,600	⅛	200000
Sulphur	2,200	¼	10000
Nitrogen in Air	70 millon lbs over an acre.	100	700000

The 2 million pounds of soil are taken as the weight of an acre of soil 6 2/3 inches deep. The 100 bushel of corn as given by the table is not the average yield but is above average by four times thus the danger of depletion is removed still further.

The nitrogen of the soil is more liable of depletion than any of the others, for it is removed in larger quantities and it is found in the organic matter only and not in the mineral matter of the soil. The organic matters or humus give up their nitrogen in avaible form by a process, knownasnitrification, brought about by important group of soil organisms or putrifactive bacteria, which break down the highly complex nitrogenous proteid compounds of the humus into simpler amido-bodies and these still further into compounds of ammonia. These ammonia compounds in turn are oxidised and converted into nitrates by different kinds of these micro-organisms. Before the change into nitrate, ammonia compounds undergo a change into nitrites. Each of these steps is carried out by specific bacteria or ammonifying bacteria, nitrite bacteria, and nitrate bacteria.

Several conditions must be favorable before nitrificationcan occur. The temperature must be adequate, for at five or six degrees centigrade the process stops, thus in winter it does not go on and in summer when the temperature is about 24 degrees centigrade it proceeds at a rapid rate. The presence of an alkali is absolutely necessary as well as a proper amount of moisture. If the soil is deficient inair the organisms cannot carry on their work, hence their inactivity in water-logged soils.

Now it is up to the farmer to bring about the conditions necessary to promote the activity of these organisms, by good tillage careful drainage and occaisional applicationof ime to soils which are dificient in it.

We saw the activities of one of the several series of these organisms which are found in huge numbers in the soil, others are responsible for many other importantchemical processes which as a whole make the soil constituent more avaibleand betteradapted to nutrition of plants. In one cubic centimeter of soil, taken from the surface, from a million and a half to two millon of these organisms can be counted out . The lower depths contain a lesser mumber of them.

All the manures applied to the soil undergo, sooner or later, decomposition under the influence and agency of one or other kind of these micro-organisms or else their application would be useless. The fact that the action of living organisms is the cause of the production of these results is supported and proved by the fact that their action ceases when the soil, containing them, is heated or treated with disinfectants which destroy or check their life and growth.

An important group of these soilorganisms are known to have the power of using the free nitrogen of the air for the formation of complex nitrogenous compounds and these compounds in turn are broken up into simpler nitrogenous compounds as we saw before. This power of "fixing of nitrogen" is not possessed by higher green plants. The organisms cling to nodules of the roots of certain group of plants and by feeding upon them, carry on their function. The best known example of a class of plants, which allow the bacteria to feed upon their carbohydrates and in exchange use up the nitrogenous compounds formed, are clover, peas, beans etc, and the class as a whole is called leguminosae. The soil upon which these plants are grown become richer in nitrogen due to the nitrogenous root residues left in the land. Not all soils contain this type of the organisms essential for legume plantation hence the frequent need of inoculation of the soil upon whichlegume plants are to be grown by the soil of the same legume plant, for each legume has its own characteristic type of bacteria, some being common to two or more legume plants. The process of the inoculation is very simple. A wagon load of the soil, known to be infected by them, is spread over anacre of the soil to be inoculated, and harrowed and disked in to avoid exposure to sunlight which tends to destroy the bacteria. Artificially prepared cultures as a rule have proved unsatisfactory. Another and by far a better and more uniform method of inoculation is by moistening the seed with a 10 per cent soluti[illegible] ly sifting over them sufficient dry pulverized infected soil. The seeds now may be planted within a day or spread out to dry in shade and planted later in the season.

The difference between alfalfa soil treated with bacteria, and another devoid from it, and other combinations can be easily caught by the following table.

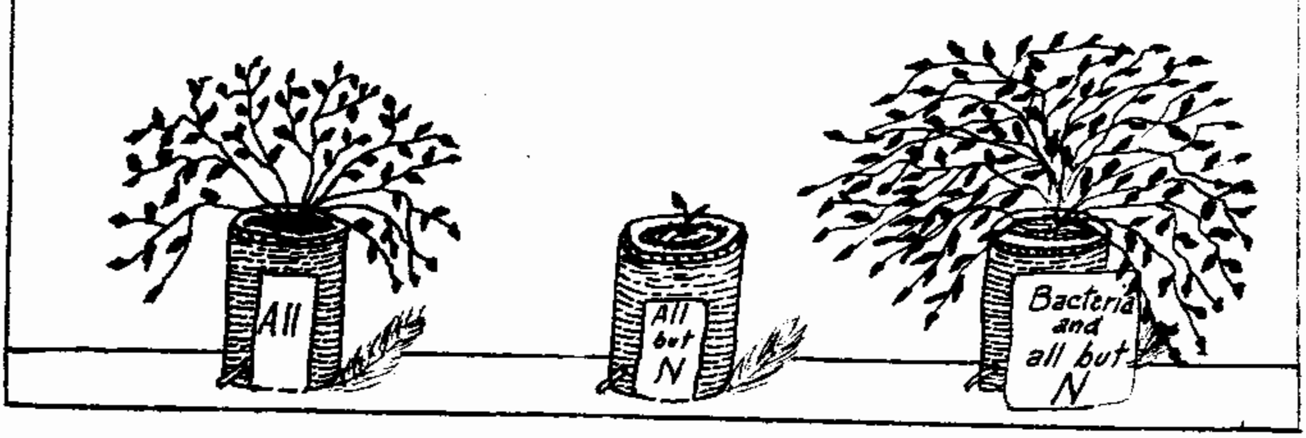
Fixation of nitrogen by alfalfa in field culture.
Illinois experiments on common prarie land.
(from soil fertility and permanent agriculture by Cyril)
(G. Hopkins)

Plot No	Treatment applied	Dry matter in crop lbs	Nitrogen in dry matter per cent	Nirogen in crops lbs.	Nitrogen fixed by bacteria
1 a	None	1180	1.85	21.81	-----
1 b	Bacteria	2300	2.70	62.04	40.23
2 a	Lime	1300	2.02	26.20	------
2 b	Lime, Bacteria	2570	2.65	68.02	41.82
3 a	Lime, Phosphorus	1740	2.03	35.40	-----
3 b	Lime, Phosphorus Bacteria.	3290	2.71	89.05	53.65

The following diagram, too, will represent a clear notion ofwhat bacteria does and what place nitrogen has as plant food. The plants in the pots are clover which needs no nitrogen to start it.

(from soil Fertility and Permanent Agriculture by)
(Cyril G. Hopkins)

All three pots planted at the same time.



So much for the constructive and beneficial part of these organisms. We shallnow consider other types.

Several group of bacteria, related to the above, counteract the nitrification process and cause the loss of nitrates by their denitrifying power that is the process becomes reversed and nitrates are changed into nitrites and nitritesinto ammonia and gaseous nitrogen which escape into the atmosphere. These types of bacteria are abundantly found in fresh dung and old straw but [illegible] on their work extensively in presence of oxygen for they are anaerobic bacteria and do better absence of oxygen as in water-logged and badly tilled soils. Thus tilling removes the danger of too much loss of nitrates.

All this knowledge and investigation about micro-organisms in soil is of a recent date. Before this progress on this line, soil was looked upon as a dead inert material containing certain chemical substances which served as plant food constituents, and almost no notion of the presence of these myriads of micro-organisms and their most vital function to all life existed anywhere. The fungi of certain types may be grouped under these organisms as regards the importance of their chemical action.

The permanent productive capacity of a soil can be determined by noticing the proportion of the food constituent that can be extracted by strong hydrochloric acid. This determination does by no means state that the food thus extracted is in a condition to be taken up by the roots of plants but may correctly be said to be in a dormant state whichmay become available by tillage. The cropping power of a soil may be determined approximately by treatment with N/5 hydrochloric acid, and removal of silicates be evaporating to dryness ignition and extraction with HCl again and filteration. This solution is again evaporated to dryness and residue weighed and percentage calculated. Another more reliable determination of this nature wes introduced by Dyer who dissolved out mineral food constituent of soil with a 1% solution of citric acid, which represents about the average acidity of the root of most common plants, with better results.

Before closing this chapter it isappropriate to grasp the methods of the determination of the chemical plant food constituents of the soil. In practice we never need to know the percentage of all the chemical constituents of the soil because for all practical purposes in agriculture only the amount of nitrogen, phosphorus and potassium would do.

The method of collecting soil samples for the following procceedures I shall give in the third section of this essay.

Nitrogen Determination
(from soil fertility and permanent agriculture by Cyril)
(G. Hopkins)

Nitrogen is determined by the regular Kjeldahl method. Ten grams of soil (five grams if high in nitrogen) are weighed into a Kjeldahl flask, 20 Cc.of strong sulfuric acid (more if necessary) and approximately 0.65 gram metallic mercury added and the contents of the flask digested until colorless. Oxidation is completed by adding, while still boiling hot, powdered potassium permanganate until the solution is green. It is then allowed to cool and 250 Cc. of nitrogen-free water added to the content of the flask and enough strong alkali solution added to more than neutralize the acid. The flask is then immediately connectedwith a still, the ammonia distilled off and collected in a flask containing a measured amount of standard sulfuric acid. The excess of sulfuric acid is then titrated back with ammonium hydroxid, and the amount of nitrogen in the soil calculated.

Phosphorus Determination

(A combination of the processes given in Practical)
(agricultural chemistry by Auld and Ker and in Ag-)
(ricultural chemical analysis by percy F. Frank -)
(land)

Five grams of the fine earth (our sample) are boiled in an open flask with 10 to 15 Cc. of concentrated hydrochloric acid for a short time, with constant shaking, in order that the acid may attain constant strength. The flask is then loosely stoppered with a funnel, a and the contents digested on the water-bath for forty-eight hours. The mixture is filtered while hot, through a Buchner funnel(sucktion funnel), washed thoroughly with hot water and the filterate and washings evaporated to dryness in a porcelain dish and ignited, the residue is again taken up with hydrochloric acid, filtered, again evaporated to dryness, and heated for half an hour at 105 degrees centigrades. The residue is now disolved, as far as possible in dilute nitric acid, filtered and make up to about 50 Cc.. To the solution is added several grams of ammonium nitrate and 50 Cc. of ammonium-molybdate solution. The mixture is allowed to stand in a warm place for 24 hours, the yellow precipitate filtered off, and washed thoroughly with one per cent nitric acid. Dissolve the precipitate both on the filter and that remaining in the beaker in warm diluteammonia, passing the whole through filter; nearly neutralized with HCl and the phosphoric acid precipitated with magnesia -mixture. Then precipitated filtered washed with ammonia (one part ammonia to 3 parts of water) dried, ignited and weighed as magnesium pyrophosphate ($Mg_2P_2O_7$), and the result multipliedby the factor 0.27838 to give us pure phosphorus.

Potassium Determination

(A combination of the processes given in Practical)
(agricultural chemistry by Auld and Ker and in ag-)
(ricultural chemical analysis by Percy F. Frank-)
(land)

The solution of potassium determination is prepared and treated as in the case of phosphorus determination except the residue is taken up after the second evaporation with dilute HCl instead of nitric acid. To the solution is added 5 Cc. of a 5 per cent solution of platinic chloride and the mixture carefully evaporated on the water-bath almost to dryness . The residue is treated with 80 per cent alcohol and digested for several hours in alcohol of the same strength then thrown upon a weighed filter and washed with alcohol. The precipitate is then dried at 100 degrees centigrades until of constant weight. The precipitate is potassium platinic chloride ($2KCl$ # $PtCl_4$ or $PtCl_6$). The result is multiplied by the factor 0.16118 to give us potassium alone.

SECTION II

The Value of such a survey

Up to this time we have been dealing with principles which were established and promulgated by other investigators and all we had to do was topractice them and apply them according to the wording of the principles. The more important part of our soil knowledge and soil handling begins when we combine these principles with actual daily experience and skill, for here we are given to choose among the many methods of soil treatment and our success will wholly depend upon our quickness in observation and selection of the best. As I intimated before, a soil survey of a region treats of the different types of soil of thatregion and their relation to crops particular to their nature and the local climate. This could hardly be accomplished in a short time even of a very limited area by a single person. The data at the end of this thesis is all that has beenaccomplished as far as an actual soil survey is concerned. Due to deficiency of personal experience I shall simply present in this the second section of the work the available plant food, the crop requirements, the relation of the crops to the requirement and the means best adopted for conservation of soil fertility, in general and not to any particular type of soil of the Beirut plain. In line with this discussion I shall give a table and a brief method of land evaluation.

This thesis will have served its purpose and the writer will have realized his end if it succeeds in showing those concerned three vital points; 1st the unsatisfactoriness of their present practice in agriculture, 2nd the enormous possibility of the future and 3rd the interest they should take in scientific management of their land. The present practice of farming in Syria is hardly better than theways primitive man adopted. The few successful crops that they may get are principally chance crops and unexpected. As an instance, though referring to a place in Palestine and not Syria, I recall a very remarkable instance of ignorance in land management in this part of the world. Ten years ago the Carmel mountain flourished and groaned under the weight of one of the most productive vineyards of the world. The farmers were unable to carry to the market all their products of grapes and large amounts would go to waste due to neglect because of the inability of the farmers to pick them all. Within two to three years all of this verdure and prosperity was reduced to small insignificant patches and these too by the by vanished and no sign of the past remained. The mountain became denuded of their grape-vines almost overnight. Why? No one knows. Up to the present time the mountain refrains tonourish satisfactory vines or other plants as she did in the past. Now if there had been aby man with scientific endowments in that region he would have found the trouble and prevented the disaster. This , and many other cases of the kind, all the more indicate in what a great need is this country for an advanced science of agriculture. May this essay serve as a nucleus for the future pioneers to construct upon and to encourage modern ideas and systems of cultivation. Has not the country in its interest in other affairs neglected that which is of primary importance, namely the proper cultivation of the land. The Syrian plains are rich and very promising and of high future possibilities and by the proper attention of her citizens should yield abundantly.

Chapter 1.

Available Plant Food

In judging the value of the food constituent of the soil it is necessary to take into account not only the total amount of phosphorus, potassium and nitrogen which it contains but also the proportion of each which the plants are able to utilize readily. There are many soils which are very rich in one or more of the above constituents in such insoluble form that they are of little immediate benefit to crops which case is specially true of soils of granite origin. It is true that these food constituents are not lost to the soil by leaching but with the modern system of intensive farming the farmer cannot afford time to wait until they become available, and what he does is to resort to stimulents or commercial fertilizers in which connection the term "available" was first used. The argument was based upon the supposition that soils do not contain available food as do fertilizers which is totally fallacious for experiments previously described actually prove the existence of part of the plant food in available form.

Besides the application of fertilizers, there are other practical methods of increasing and rendering plant food in the soil available. The most economical method would be the adoption of a system of farming which makes plant food available in the soil without subsequent loss. By estimating the plant food removed in the crop and taking into consideration the extent of leaching we can easily determine the amount of phosphorus a soil should contain in order that what it supplies in available form will meet the above requirement, assuming that 2 per cent of nitrogen, 1 per cent of phosphorus and 0.25 per cent of potassium could be made available during one season and under normal conditions. What the soil contains of plant food suffices for a large number of crops but all the question lies in how fast this store of food is made available. This fact complicates the evaluation of lands for there may be lands poor in plant food content and still give out available plant food at rapid rates while other tracts of land may possess just the reverse properties. In general the soils of the latter type pay more than the former for they can easily be made to furnish available food in sufficient quantities by lime or other soil stimulent application, while the former is always in danger of total depletion and destruction.

The plant food is made available by the action, of the acids, chiefly HNO_3 and H_2CO_3, resulting after the decomposition of decaying organic matter, and plant rood exudations as well. The roots of plants are known to excrete acids which attack the insoluble plant food and render it soluble or available, for the sap of all plants with which they have direct connection are distinctly acid. Roots have been noticed that have etched polished marble upon which they have crowled.

Most recent experiments have shown that what effort the farmer may put into applying available food, fertilizers, except nitrates, is, in the last analysis, merely an effort at more equal distribution of the plant food in the same state as it is in the soil. Experiment has proved that the moment the fertilizers are applied they are dissolved in water and the solution makes a coating over all the soil particles in an insoluble form and this equal distribution and increased surface merely gives more chance to plant root acids to act and thus remove more plant food. Insoluble plant food would not afford the same chance to the plant roots for they do not dissolve in water to form the coating around the particles unless they be very finely powdered and well spread.

Food in available form in the subsurface and subsoil does not contribute much to the productivity of crops. It would be better if the subsurface and subsoil soils acted as reservoirs for the surface soil and the surface soil contained all the necessary food. The leached out plant food, as potassium, may be sought out by plants which may thus utilize as much of the plant food as they need. Despite all this, potassium is found, as a result of leaching, in increasing amounts the deeper it goes. The physical properties of soil if on proper bases will enable plants to go deeper in search of water and of such available food on their way down. The subsurface and subsoil are very poor in plant food as far as nitrogen is concerned for they are deficient in organic matter and no considerable amount of nitrogen is leached down from the surface soil.

A theory was launched in the beginning of the present century in connection with plant food availability by some American agriculturists chiefly Professor Whitney, Chief of United States' Bureau of Soil and Dr. Cameron, Chief Chemist of the same Department, that all kinds of soil contain the plant food in sufficient amount and available form to give rise to rich and profitable crops indefinitely were it not that the plants suffer from one anothers excrements. They said every plant excretes through its roots substances which are poisonous to the new generation of their own species and to some others not of the same species and what the fertilizers do is to neutralize their poinning properties. They based their argument upon the familiar fact that trees cannot prosper if planted in places where another tree of the same kind was frourishing the year before and also that fertilizers do not show their effect until some time has elapsed or the sweetening process has been carried far enough. As the theory has not as yet been recognised by ninty-nine per cent of the distinguished agriculturists of the world we need not dwell much upon it except before passing to the discussion of crop requirements, to state that everybody wished it were so, but they cannot favor it for no doubt exists as to the fact of the impoverishment of soils by crops, after the lapse of time; and they know that no such impoverished soils have been observed to attain their former fertility even after centuries. The worn out abondoned farms of the Eastern U.S.A. are typical examples.

Chapter 2.

Crop Requirement

The demand of different crops for plant food from soil, taken on an average, is the same for most plants, with some exceptions, which seem to be, in certain cases, not directly connected with the requirements, as the the case of calcium for legumes. All the plants at one period of their life time bear seed and the germs of these seeds are rich in phosphorus potassium and nitrogen. Now the problem is how much of these seeds different crops produce which determines what they mainly remove from soil and what their requirement is. The stalk and the straw too, remove of the food elements in considerable amounts and should occupy their proper place in the bill of crop requirements. Crops such as cotton, sugar beet, potatoes, remove more potassium than the other elements and do not yield well if not given potassium in the form of commercial fertilizers.

The following table based upon averages of large numbers of analysis of normal products will demonstrate the three main constituents of different crops, from which we can easily form an idea of the quantity of the different plant foods which crops require and the value of each in ordinary times.

Fertility in Farm Produce
Approximate maximum amount removable per acre annually
(from Soil fertility and permanent agriculture by)
(Cyril G. Hopkins.)

Produce		Pounds			Money Value			
Kind	Amount	Nitrogen	Phosphorus	Potassium.	Nitrogen	Phosphorus	Potassium	Total value
Corn grain	100 bu.	100	17	19	$15.00	$0.51	$ 1.14	$16.65
Corn stover	3 T.	48	6	52	7.20	0.18	3.12	10.50
Corn crop	-------	148	23	71	22.20	0.69	4.26	27.15
Oat grain	100 bu.	66	11	16	9.90	0.33	0.96	11.19
Oat straw	2½ T.	31	5	52	4.65	0.15	3.12	7.92
Oat crop	-------	97	16	68	14.55	0.48	4.08	19.11
Wheat grain	50 bu.	71	12	13	10.65	0.36	0.78	11.79
Wheat straw	2½ T.	25	4	45	3.75	0.12	2.70	6.57
Wheat crop	-------	96	16	58	14.40	0.48	3.48	18.36
Soy beans	25 bu.	80	13	24	12.00	0.39	1.44	13.83
Soy b" straw	2¼ T.	79	8	49	11.85	0.24	2.94	15.03
Soy b crop	-------	159	21	73	23.85	0.63	4.38	26.86
Timothy hay	3 T.	72	9	71	10.80	0.27	4.26	15.33
Clover seed	4 bu.	7	2	3	1.05	0.06	0.18	1.29
Clover hay	4 T.	160	20	120	24.00	0.60	7.20	31.80
Cowpea hay	3 T.	130	14	98	19.50	0.42	5.88	25.80
Alfalfa hay	8 T.	400	36	192	60.00	1.08	11.52	72.60
Cotton lint	1000 lb	3	0.4	4	0.45	0.01	0.24	0.70
Cotton seed	2000 lb	63	11	19	9.45	0.33	1.14	10.92
Cottonstalk	4000 lb	102	18	59	15.30	0.54	3.54	19.38
Cotton crop	-------	168	29.4	82	25.20	0.88	4.92	31.00
Potatoes	300 bu.	63	13	90	9.45	0.39	5.40	15.23
Sugar beets	20 T.	100	18	157	15.00	0.54	9.42	24.96
Apples	600 bu.	47	5	57	7.05	0.15	3.42	10.62
Leaves	4 T.	59	7	47	8.85	0.21	2.82	11.88
Wood growth	1/50tree	6	2	5	0.90	0.06	0.30	1.26
Total crop	-------	112	14	109	16.80	0.42	6.54	23.76
Fat cattle	1000 lb	25	7	1	3.75	0.21	0.06	4.02
Fat hogs	1000 lb	18	3	1	2.70	0.09	0.06	2.85
Milk	10000 lb	57	7	12	8.55	0.21	0.72	9.48
Butter	400 lb	0.8	0.2	0.1	0.12	0.01	0.01	0.14

The succeeding table gives us an idea of the amount of the principle food elements which mature trees (in this case only fruit trees) remove directly from the soil during a season's growth under normal condition

Plant food used during a season's growth by a mature fruit tree in full bearing.
(from U.S.'s Farmers Bulletin)

Variety	Nitrogen lbs.	Phosphoric acid lbs.	Potash lbs.	Lime lbs.	Magnesium lbs.
Apple	1.47	0.39	1.57	1.62	0.66
Peach	0.62	0.15	0.60	0.95	0.29
Pear	0.25	0.06	0.27	0.32	0.09
Plum	0.25	0.07	0.32	0.34	0.11
Quince	0.19	0.06	0.24	0.27	0.08

The time and temperature make a great variation as to the degree of requirement, as in the earformation and "filling season" more plant food is used than at the close of the season.

Next to the examination of crop requirement it will be appropriate to get a general view of the relation of crops th these requirements. The mediumswhich set up a relationship between plant and its requirement are factors whose favorableness an unfavorableness produce distinct effects and changes in the crop production. The factors are light, air, temperature and moisture conditions for the growth of the leaves, stems, fruit or seeds of plant. The change in these factors,which is naturally expected, bring about critical periods in the life of plant as in the time of ear forming, special supply of plant food appears to be necessary. With deficient supply of any of the requirements crops acquire a pale yellow color which may be due to "nitrogen hunger" or any other hunger. While on the other hand they mature earlier if the requirements are well balanced and do not suffer if they be over and above the amount necessary. At times these factors create such a state of affairs that even with presence of requirements plants cannot adopt themselves, to the created enviroment and this is why plants of the temperate, tropical and arid zones differ so much from one another and cannot exchange homes. Some of the plants have created such characteristics that they can bear one climate and not another, as rice crops cannot be cultivated on areas other than humid, while other cereal crops can withstand with patience less humid conditions. Tea plants must have proper drainage andheat or else they would not grow.

Potatoes grown on the same land for 15 years consecutively stopped to yield on the sixteenth year and when barley was planted over this same soil a yield of 75 bushels per acre was obtained which shows crop requirements were not deficient but that the excreta of potatoes increased so much as to hinder it from removing their requirements or it caused its own self-poisoning although not poisonous to barley. With these factors in mind we may well consider the following statement from Whitney, in U.S.'s Farmers Bulletin 257.

"Apparently, these small amount of fertilizers we add to the soil have their effect upon their toxic substances and render the soil sweet and more healthful for growing plants. We believe it is through this means that fertilizers act rather than through the supplying of food to the plant"(page 20).

"There is another way in which the fertility of the soil can be maintained; viz, by arranging a system of roration and growing each year a crop that is not injured by the excreta of the proceeding crop; then when the time comes around for the first crop to be planted again the soil has had ample time to dispose of the sewerage resulting from the growth of the plant two or three years before ----- Barley will follow potatoes in the Rothamsted (anEnglish agriculturat experiment and research station) experiments after the potatoes have grown so long that the soil will not produce potatoes. The barley grows unaffected by the excreta of potatoes, another crop follows the barley, and the soil is then in condition to grow potatoes again.

"In other experiments of Lawes and Gilbert they have maintained for 50 years a yield of 30bushels 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 year after year for 50 years without fertilizers from 30 bushels to 12 bushels, which is what they are now getting annually from their unfertilized wheat plots. With a rotation of crop without fertilizers they have also maintained their yield for 50 years at 30 bushels, so that the effect of rotation has in such case been identical with that of fertilization"(page 21, 22).

Other minor factors create similar changes and results but their further describibg will divert us from our main subject and the above statements have been sufficient to acquaint us with the main points.

Chapter 3.

Conservation of soil fertility.

The conservation or maintenance of soil fertility is a very difficult subject and so intricate in detail, and dependent upon so many local and variable conditions that it cannot be treated in this essay in other than by a general discussion of the subject.

The practice of the main agricultural operation of humid sections of the world, the conservation of soil fertility has been acquired through centuries of experience, and is based upon three chief methods. The first method is fertilization, or manuring, which is the most generally practiced, the second, crop rotation also widely practiced and becoming very important and the third is by proper culture and tillage including drainage and irrigation not well appreciated and little practiced. Another plan for permanent soil maintenance or of soil improving woild be the adoption of three other systems between which and the above there is considerable similarity. They are as follows :-

(1) To secure nitrogen from the inexhaustible supply in the air.
(2) To liberate potassium from the practically inexhustible supply in the soil.
(3) To return phosphorus to the soil in some form in as large or larger amounts than are removed in crops.

These methods only touched the feeding factor while other factors are just as important, for plant, to subsist, must drink, breath and have a proper sanitary enviroment, just as much as they should feed. Let us take up in brief some of these topics each by itself.

Fertilization Method

Fertilization always has been and without duubt always will be the principle method in permanent soil maintenance. But enormous quantities of fertilizers are wasted annually especially the farm manures, by improper handling and exposure to air. There are different kinds of fertilizers, all of which serve to bring about fertility, but some, as the commercial fertilizers, not having all the constituents of plant food are applied to land deficient in them only. Usually the commercial fertilizers are accompanied with farm manure or any other nitrogeneous matter with the best results. Farmers choose fertilizers which can be obtained as cheaply as possible and in large amounts with proper degree of solubility and fineness. The following table on page 25 gives us a key to the value of the different fertilizers in the market and on the farm in normal times. The table treats only of the three main plant foods but occaisons arise at times that calcium becomes deficient when ordinay limestone will be an economical resource.

Before resorting to fertilization methods the soil should first be examined either in the laboratory, or by experiment on the field itself, for the amount of its available food. Appearance of plants does not ordinarily indicate the lack of one element or another, for the lack of any of them may be indicated by the same signs. The newest method for determining the amount of fertilizers and, of which paricularelement a soil lacks, was discovered by Professor Whitney. The procedure is to take a basket made of wire netting with about one-eighths inch mesh and dip the rim in melted parafin until a little ring or band of parafin isformed around the top. It is then filled, and pressed, with the soil to be tested which must have the right amount of moisture. When the soil is filled to one-half inch from the top we brush off the soil which may project from the meshes and then dip all, to the parafin rim, into melted parafin quite hot. The purpose of dipping the rim of the basket in hot parafin is to complete the side of the pot, above the soil, which could not be dippedso deep in the parafin after the pot was filled with the soil. We do the same for other samples of the same soil with different fertilizers in it and a seed of a plant in each one, and watch their growth. If the growth be the same in all no fertilizer is needed if not, we add the fertilizer which gave the best result. The principle involved in the test is that aeration factor is eliminated and so the soil shows exactly its growing conditions for if aeration were allowed all seeds would grow on good and bad soils with practically no difference as is noticed when such experiments are performed in earthen pots. This method is more practical and more reliable than the chemical method, will take three weeks to decide and can be used to give any other kind of information we might need.

Rotation method

Rotation method is a succession of different crops onw following the other on the same land. The principle involved is to secure nitrogen, from the inexhaustible supply in the air by [illegible]
which enrich [illegible]

point of view of Professor Whitney it is the sweetening of soil for the succeeding crop by growing crops alternatively which do not mind the poisonous excreta of the previous crop. The system may be practiced in a fixed and definite order that is at regular intervals.

Fertility in Manures rough feeds and fertilizers.
(from the "Soil fertility and permanent agri-)
ture by Cyril G. Hopkins. ********)

Name of Material	Pounds per ton			Market value per ton			
	Nitrogen.	Phosphorus.	Potassium	Nitrogen.	Phosphorus.	Potassium	Total value
Fresh farm manure	10	2	8	$ 1.50	$ .24	$ .48	$2.22
Barnyard manure	10	3	8	1.50	.36	.48	2.34
Corn stover	16	2	17	2.40	.24	1.02	3.66
Oat straw	12	2	21	1.80	.24	1.26	3.30
Wheat straw	10	2	18	1.50	.24	1.08	2.82
Clover hay	40	5	30	6.00	.60	1.80	8.40
Cowpea hay	43	5	33	6.45	.60	1.98	9.03
Alfalfa hay	50	4	24	7.50	.48	1.44	9.42
Dried blood	280			42.00			42.00
Sodium nitrate	310			46,50			46.50
Ammonium sulfate	400			60.00			60.00
Raw bone meal	80	180		12.00	18.00		30.00
Steamed bone meal	20	250		3.00	25.00		28.00
Acidulated bone meal	40	140		6.00	16.80		22.80
Raw rock phosphate		250			7.50		7.50
Acid phosphate		125			15.00		15.00
Double superphosphate		400			48.00		48.00
Basic slag phosphate		160			16.00		16.00
Potassium chloride			850			51.00	51.00
Potassium sulfate			850			51.00	51.00
Kainit			200			12.00	12.00
Wood ashes		10	100		1.20	6.00	7.20
"Complete fertilizer"	33	88	33	(?)	(?)	(?)	23.00?

One satisfactory rotation plan for grain farmers is wheat ,corn, oat and clover; or wheat, corn and cowpeas; or cotton, corn, and oats and cowpeas. The stalk and all besides the grain, seeds and cotton lint should be returned to the soil and at times or after the lapse of four years agreen legume crop to be turned under.

As to the process and the agency by which the legumes enrich the soil, this has been stated in the previous pages. The other effects of rotation are to avoid the accumulation of poinsonous weeds, disease and insects on the farm.

The plant ;ests peculiar to a crop multiply so quickly under one crop system that it becomes imposible to secure profitable returns from the soil, no matter how satisfactory the other factors may be. The rotation system acts as a resistant against these pests for in the plans given above the one crop following the other does not become subject to the pests of the one before.

Plants must breath

Plants, just as the members of the animal kingdom, need oxygen to feed upon, anda chance to get rid of noxious gases as CO_2 and others. The leaves do most of the breathing of the plant and the roots apparently take part in the performance of this function. But the roots give off at the same time gases which if they do not escape through the soil would poison them just as people in a crowded room with no ventilation, after a while would feel drowsy and have head aches due to poisoning. Cases are known where trees have been poisoned by the escaping gas from the illuminating gas pipe leakage in the streets. This fact shows the very great importance of ridding the plants by proper methods of tilling of noxious gases formed by their roots, Though this does not seem to affect the fertility, but without the slighest doubt does increase the yield, it may be considered an indirect means of permanent soil maintenance. This tillage may further the possibility of a better drinking system for plants, as well, for it is an ordinary saying that we must render the moisture of the soil available for absorption by the roots. The fact is that it is not the water that seeks the roots but the roots which go after the water. The phenomena of capilarity is slow in its action and almost negligible for the soil particles grip the waterso hard. Experiments actually have shown that the dry layer on the top of a soil prevents evaporation more than a moist layer, which shows the action of capillarity to be very slow. Now by proper tillage the plant roots will be given the opportunity to grow more freely and run away from their poisonous matter which they eject. It is for this reasn that a new root after a day or two of drinking corks over, that is it is coated over with a corky tissue, to avoid the poisonous excreta, while the tip of the root keeps on growing, drinking and little by little corking over. This was a very indirect method of conservation of soil fertility.

Plants must Feed

The discussion of this topic again brings us to Professor Whitney and Dr. Cameron, whom I have quoted before. Very few agricultural subjects can be treated without reference to these two men. They put the question of soil fertility in such a situation that many problems of agriculture are diminished that is they say that if the farmer were able to extricate the plant excreta from the soil, fast enough by whatever methods that prove successful, he could cultivate his land every year and the fertility would not fail. This theory undermines all other attempts for maintaining soil fertility. They say that plants have an extra-ordinary power for absobing material from solution and all obstacles in the way of this absorption and extraction be removed, plants will have sufficient and even more than sufficient to feed upon from soil solutions which contain appreciable amounts of dissolved mineral plant food in them. As an example they suggest the sea weeds which extract iodine from sea water, which has so little iodine in it that we cannot detect this element with our most delicate methods of analysis even though we concentrate it to a very small part of its original bulk. The methods of gettting rid of the soil excreta, they maintain to be something like oxidixing by bacterial agencies and cultures.

In the future if this soil theory of fertility should be established and methods for its practice be discovered, it will replace the present tedious methods for soil maintainance, and then no land will be termed as worn out or depleted.

These theories at present however do not do a bit good to the farmer, as long as he cannot put them into actual practice, (in the ideal and Utopian may that is with little expenditure of energy and money), and he and his land will be tired out if he waits until they assume workable shape. The best and wisest method for him wuuld be to combine the already successful methods for maintenance of soil fertility as given above with his own daily experience on the farm; at the same taking full consideration of economy of time, money and energy, and any practical discoveries in the line of his profession.

Chapter 4.

Evaluating land.

Land evaluation emphasixes the importance of producing and maintaining large crop yields, for lands increase in price with geometrical progression as the yield increases in arithmetical progression. That is, if a land which produces a 20 bushel crop of corn is valued at $21.81 an acre; a double yield of the same land multiplies the value more than five times. Land values have always been, (for farming purposes only) measured by crop returns, at average market price, which in most cases comes out right. But at times it becomes somplicated for there are lands which actually are becoming impoverished by soil stimulent application., while in appearance their yielding quality is high. An examination by the parafin pot method will give sufficient data for valuation but not in the case of a stimulated land where it totally fails and the soil has to be subjected to chemical methods of determinations. In evaluating land, the expensesof the crop it has to yield, and the local lacal land tax are taken into account. The allowence for land tax as taken in U.S.A. is a uniform rate of half a per cent of the actual valuation of the land which is fixed by its interest-earning capacity of 5 per cent or in the last analysis ten per cent of the interest. In many countries the taxes of land are for local purposes as schools, roads, bridges etc with little or no distinction between the poor and the rich lands that pay them. The locality of the land will make a difference in its value, for the local taxes increase if the lands, are near the cities and decrease for those further from the cities. A careful consideration of the following table, on page 28, will give us the relative value of land of different yields and clearly indicate that yields slightly below the figures given make the land practically valueless for buisness or investment purposes.

The above method of local valuation is adopted, in U.S.A. or in Europe where the net work of railways practically equalizes the value of the farms of the same degree of fertility, and not in this part of the world where seldom do railways cross such fields. This drawback in this country makes a marked change in the value of l[illegible] are given values accorking to the rate of freight from their location to the city or village where their products sell best.

Value of land measured by crop yields.
(from soil fertility and permanent agricul)
(ture by Cyril G. Hopkins.)

Corn yield per acre	Gross value of crop	Annual expense, per acre.					Net value of crop.	Net value of land per acre.
		Soil treatment.	To grow crops	Harvest and Market	Taxes on land	Total annual expense		
An acre of wheat at 75 cents a bushel.								
10 bushels	$ 7.50	$1.00	$3.00	$1.00	$0.23	$ 5.23	$2.27	$ 45.45
20 bushels	15.00	2.00	3.00	2.00	0.73	7.73	7.27	145.45
30 bushels	22.50	3.00	3.00	3.00	1.23	10.23	12.27	245.45
40 bushels	30.00	4.00	3.00	4.00	1.73	12.73	17.27	345.45
50 bushels	37.50	5.00	3.00	5.00	2.23	15.23	22.27	445.45
An acre of corn at 40 cents a bushel.								
20 bushels	$ 8.00	$1.80	$4.00	$1.00	$0.11	$ 6.91	$1.09	$ 21.81
40 bushels	16.00	3.60	4.00	2.00	0.58	10.18	5.82	116.36
60 bushels	24.00	5.40	4.00	3.00	1.05	13.45	10.55	210.91
80 bushels	32.00	7.20	4.00	4.00	1.53	16.73	15.27	305.45
1oo bushels	40.00	9.00	4.00	5.00	2.00	20.00	20.00	400.00
An acre of oats at 30 cents a bushel.								
20 bushels	$ 6.00	$0.50	$3.00	$1.00	$0.14	$ 4.64	$1.36	$ 27.27
40 bushels	12.00	1.00	3.00	2.00	0.55	6.55	5.45	109.09
60 bushels	18.00	1.50	3.00	3.00	0.95	8.45	9.55	190.91
80 bushels	24.00	2.00	3.00	4.00	1.36	10.36	13.64	272.72
100 bushels	30.00	2.50	3.00	5.00	1.77	12.27	17.73	354.54
An acre of clover at $ 6 a bushel for seed.								
1 bushel	$ 6.00	$3.00	$1.00	$1.50	$0.05	$ 5.55	$0.45	$ 9.09
2 bushels	12.00	3.00	1.00	3.00	0.45	7.45	4.55	90.91
3 bushels	18.00	3.00	1.00	4.50	0.86	9.36	8.64	172.72
4 bushels	24.00	3.00	1.00	6.00	1.27	11.27	12.73	254.45
5 bushels	30.00	3.00	1.00	7.50	1.68	13.18	16.82	336.36
Average for the four year rotation								
	$ 6.88					$ 5.59	$1.29	$ 25.80
	13.75					7.98	5.77	115.40
	20.63					10.38	10.25	205.00
	27.50					12.77	14.73	294.60
	34.38					15.17	19.21	384.20

In general lands on the banks of a navigable river have specially good values, as any other land would have which may have a favorable situation for the transportation of its products. Mountain lands separated from cities and isolated by bad roads or lack of roads attain low values. Lands in danger of being flooded [illegible] away by a river [illegible] lands as swamps, marshes and bogs have no value whatsoever, and breed deadly mosquitoes whichlower the price of the neighboring lands. The question of valuation of forests does notfall under the discussion of this paper and offers a subject by itself which needs agreat amount of skill, knowledge, experience and data for proper solution.

SECTION III

Survey of Beirut Plain

The heavy rainfall of Beirut district makes all kinds of soil determination, of any of its quarter unreliable for long periods of time. The precipitation of 36 inches (this year over 43.5 inches) has considerable influence upon the soil as regards leaching. The soils washed from Beirut River basin into Beirut River makes a perceptable change in the character of all the soil of the neighborhood in a comparatively short time. The north and the west sides of Beirut undergo a similar change but instead of being washed into a river they are washed out into the Mediterranean. This latter change is of a more rapid character and the extent can be commonly judged by observing the tremendous amount of soil washed into the sea, after a heavy rainfall, at times the muddy water stretches over a mile. We must remember that several such rains fall each year. The frequent barometric changes exert some influence over the physical property of the soil that is by the change inatmospheric pressure, the soil is repeatedly aerated.

Beirut district resembles a peninsula or an arm of the low hills of Lebanon stretched far into the sea. The plain is so situated that the north wind has distinctly variable effects upon its different quarters,consequently have different amounts of rainfall.

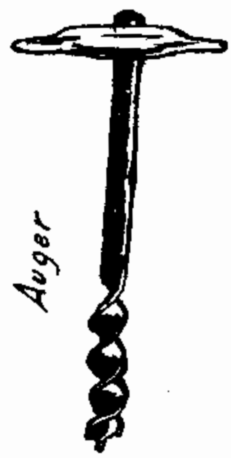
With all the above natural tendencies to bring about alterations in the soil of Beirut the constituent of its soil will remain the same with very little radical change for several decades, as the plain not being an even one is endowed with sediment from the hills and mounds i in and around it all of which show to be of the same geological structure.

On several occaisons I have offered appology for not having all the means at my disposal for an extended and ideal survey of Beirut Plain and regretfully limit myself to the presentation of a part of the survey or of the chemical determinations of ten samples from different places widely separated from one another and not particularly representing soil types. The samples are all surface soils and from within the boundary of the accompanying map which shows the spots and borings marked out. I shall append the methods followed and the tabulated form of the result along with the map. Some of the proceedures of the experiments has been given on pages 16 and 17. What remains to be described is the method of collecting and sampling of the soil.

Collecting soil samples
(from soil fertility and permanent agriculture by Cyril)
(G. Hopkins.)

10 to 20 borings of different places about a rod distant from one another are collected and thoroughly mixed. An auger of 1½ inches in diameter with the vertical lips filed off, is the most satisfactory implement to use. Only the soil of one of the two grooves of the auger is saved for both grooves represent the same layer of soil. Ordinarily surface soil samples are collected and experimented upon in which case the auger has to go down into the soil only 6 2/3 inches. If subsurface soil is to be experimented upon the next 6 2/3 inched will represent it and subsoil the third 6 2/3 inches, In all cases the hole of the above 6 2/3 inches is enlarged so as not to mix the different soils togather.

The thoroughly mixed sample after air-drying is pulverised to pass through a sieve with round holes.1 mm. in diameter. Any gravel which does not pulverise as easily as the dried lumps of clay is further pulverised to pass through a 100 mesh sieve. The soil which is now all passed through the sieve is again thoroughly mixed and the required amounts for the different determinations weighed out from it.



The Ten Samples

Mark of the Sample	Locality and number of borings
A	From near Pigion Rock; 6 borings.
B	From around the plain of Ras Beirut; 6 borings.
C	From Professor Patch's garden (S.P.C.); 6 borings.
D	From near Forn-esh-shabbak; 6 borings.
E	From near the Pine-Forest; 6 borings.
F	From near Beirut River, left or north of tram line;6 bors.
G	From near Beirut River, left of Damascus railway, 6 bors.
H	South of the Gas Company plant; 6 borings.
K	East of the tram company; 6 borings.
L	From a garden opposite the College grounds (S.P.C.)6 bors.

Mark of the sample	Nature of the Locality.
A	Luxurient plantation, ploughedland, bean and barley .
B	Ploughed and unploughed land, squash plantation.
C	From land which is probably fertilixed by cow manure.
D	Orange groves, potatoes, squash, bean, cucumber and barley
E	From around the pine groves.
F	Pasture
G	Pasture
H	From ground bearing a very rich crop of wheat.
K	Pasture
L	Potatoes, beans and uncultivated land etc.

The amount of moisture lost in the samples..

Samples	Weight in grams immediately after boring	Weight in grams after air-drying.	Amount of moisture evaporated
A	330	294	36
B	225	206	19
C	400	368	32
D	410	390	20
E	385	380	5
F	400	390	10
G	335	320	15
H	325	300	25
K	325	290	35
L	410	400	10

The result of the nitrogen phosphorus potassium determinations in the samples.

Samples	Nitrogen (N) percentage	Nitrogen (N) in 2,000,000 lbs of soil	Phosphorus(P) per centage	Potassium (K). per centage.
A	0.69608	13920	0.188	0.5222
B	0.58016	10602	0.2326	0.3972
C	0.19544	3908	0.1658	0.5208
D	0.1736	3472	0.2974	0.3094
E	0.15204	3040	0.2548	0.3352
F	0.1694	3388	0.2214	0.193
G	0.1736	3472	0.1101	------
H	0.15204	3040	0.3133	0.3159
K	0.19544	3908	0.202	0.3352
L	0.10836	2166	0.1435	0.2192

The figures in the last table show good prospects whth the exception of two or three samples. However too much stress cannot be laid upon these figures since the fertility of a soil is very greatly influenced by texture and physical constitution, perhaps more so by these factors than by chemical composition, Having in mind the above statement we can have the following as a key for judging the ten samples. Samples containing less than 1% of nitogen arelikely to be benefited by applications of nitogenous fertilizers. Where the amount of phosphorus is less than 0.05 per cent phosphatic fertilizers need be applied, while more than 0.1 per cent needs no application unless in soils containing a high percentage of iron compounds. Similarly samples with less than 0.25 per cent of potassium need special application of potassium fertilizers, while those containing as much as 0.4 or 0.5 per cent and over do not respond to fertilizers.

In conclusion, the writer would record his hope thatthe data set forth in this paper may represent the beginnings only of a complete soil survey and evaluation of the lands of Syria.

THE END

May 20 , 1919

Respectfully submitted