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TUESDAY, 23 AUGUST
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EDWARDS BROTHERS, INC.
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WATER-SOIL-PLANT RELATIONSHIPS

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   D. Franzmeier, E. P. Whiteside, and A. E. Erickson

2. THE RELATIONSHIP BETWEEN SOIL MOISTURE UTILIZATION AND ROOTING 
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3. THE RELATION BETWEEN PORE VOLUME AND THE FORMATION OF ROOT SYSTEMS 
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8. WATER-SOIL-PLANT RELATIONS TERMINOLOGY. R. O. Slatyer and S. A. 
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RELATIONSHIP OF TEXTURE CLASSES TO READILY AVAILABLE WATER

D. Franzmeier, E. P. Whiteside, and A. E. Erickson

Recently, a rather comprehensive survey of the physical and chemical properties of soil profiles representing the range of properties in Michigan soils has been made. Herein the authors have utilized the results of some of those studies to evaluate the textural classes used in the U. S. and other countries as a guide in soil correlation work. Possibly the principles involved can guide us toward a more generally acceptable textural classification of soils.

Readily available water is defined here as the difference in percentage by weight of the water content at 6 atmospheres tension and that at 60 cm of water tension. Stolzy found that these values correlated well with wilting percentage and with field capacity. The 60 cm value was determined by the blotter paper method using about 10 replicate samples from each horizon. The 6 atm value was determined by the pressure membrane method using disturbed samples. Only those soils with a low organic matter content (<0.5% organic C) and those containing a negligible amount of free carbonates were used.

The average readily available water contents of individual soil horizons were grouped according to textural classes commonly used in the United States. Soils high in the silt (.002 - .05 mm) and very fine sand (.05 - .1 mm) fractions contained the greatest amount of readily available water, while those soils having extremely coarse or extremely fine textures contained less.

The readily available water contents of these samples were also compared after grouping them according to textural classes used or proposed in Australia, Switzerland, and the Netherlands. Of these systems of classification the U. S. System gave the best segregation of samples into classes with relatively uniform readily available water contents. Marshall's right-angle diagram gave the best relationships between textural classes and readily available water of the two dimensional diagrams tried. It has the advantage that it can be used with either the International or the U. S. system of separate sizes.

A triangular diagram which gives a better relationship between textural classes and readily available water could be devised by allowing the vertices of the triangle to represent the size fractions less than .002 mm, .002 to .1 mm (silt + very fine sand in U.S.), and .1 to 2.0 mm. In figure 1 lines of equal readily available water are plotted on such a diagram. Of the 170 values plotted, about 75% fell between the adjoining equal moisture lines.

Perhaps this and similar relationships between particle size distribution and soil properties important to plant growth or other soil uses could guide us in the development of an internationally acceptable textural classification.

Fig. 1. Textural diagram with lines showing equal percentages of readily available water.
THE RELATIONSHIP BETWEEN SOIL MOISTURE UTILIZATION AND ROOTING DEPTH IN THE TROPICS

R. A. Wood

1. To assist in efficient land use planning it is essential to have a knowledge of the relative water use of field crops, pastures, indigenous vegetation and various plantation crops such as tea or coffee. Nyasaland's climatic pattern of clearly defined wet and dry seasons common to large areas of the tropics enables us to determine this by following changes in the storage of available soil moisture under various crops and fallows.

2. Work on these lines has been in progress in the territory for the last four years where the water use of several annual crops grown in various rotations has been compared with that removed by fallows kept bare, sown with a shallow rooted cover crop (teff - Eragrostis abyssinica), and those allowed to regenerate indigenous weeds and grasses. Available water has been plotted from data provided by gypsum electrical resistance blocks and initially installed at 1 foot intervals under the various treatments. Quantitative changes in soil moisture have been measured by regular soil sampling throughout the profiles, the information so obtained being converted to inches of water per foot.

Table 1 shows the amount of available water in inches held under the various treatments to a depth of six feet at the end of the 1959 growing season.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Tobacco</th>
<th>Groundnuts</th>
<th>Teff</th>
<th>Maize</th>
<th>Natural Cover</th>
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<td>Bare Fallow</td>
<td>5.60</td>
<td>3.86</td>
<td>3.60</td>
<td>3.49</td>
<td>2.25</td>
</tr>
<tr>
<td>Maize</td>
<td>5.60</td>
<td>3.86</td>
<td>3.60</td>
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Root washing studies on the mature crops and grasses have shown that these variations can be directly related to their root range and density. This relationship has emphasized the need for conserving available water under plantation crops such as tea and coffee, during the protracted dry season in Nyasaland, where conditions often reach drought intensity leading to permanent wilting and death, more especially in the younger plants where a deep rooting system has not fully developed. Root depths of up to 20 feet have been recorded under mature tea with the soil approaching wilting point at depths of 15 feet at the end of the dry season.

It is felt that the relationship between soil moisture utilization and rooting depth in the tropics for different types of vegetation in a given soil, climate and rainfall, as shown by soil storage measurements is of fundamental importance when problems of land use planning are being considered.
THE RELATION BETWEEN PORE VOLUME AND THE FORMATION OF ROOT SYSTEMS IN SOILS WITH SANDY LAYERS

A. F. Hidding and C. van den Berg

The major cause for the absence of a root system in certain sandy soil layers is often difficult to find. It may be a lack of nutrients or a deficient water- or air regime or mechanical obstruction to the penetration and secondary growth of roots, or all three combined.

In the Netherlands, soils occur over extensive areas with a thin top layer of clay or of soil with a high humus content lying on sand with a low silt and humus content, where in the sandy layers no rooting occurs. The water- and air regime of the sandy subsoil is reasonable. Although at first sight a nutrient deficiency of the sand seemed to be the reason for the absence of roots, it was found in experiments, carried out by Schuurman and Goedewaagen (1956), that applying fertilizers to the sandy subsoil had no effect on the rooting depth when this subsoil was closely packed.

One of the reasons for the carrying out of soil improvement measures, can be the impediment of root growth in certain soil layers. When advising for or against carrying out such measures in cases like this, one would like to have some easily to be determined data as criterion. In the case of nutrient deficiency this is arrived at by means of chemical analysis, in the case of air- or water deficiency the pH-curve gives a good basis.

From the mechanical point of view, rooting is governed by the pore size (penetration) and by the movability of the soil particles under root pressure (secondary growth). In general these two soil characteristics will be related. In soils with an aggregate structure pores are large and movability is high, so impediment of root growth due to mechanical resistance is generally not to be expected. Aggregate structures do not occur, however, in sandy soils with a low humus- and silt content.

Wiersum (1957) did find a good correlation between root growth in pure sand, pore size and movability. For practical purposes the determination of pore size and of movability of the particles is too complicated. It was thought that pore volume would be correlated with both. Experiments were therefore carried out to find a correlation between pore volume and root growth for the soils in question.

A great number of field samples from sandy layers of soils under rye, oats, barley and potatoes were taken. Besides that, experiments were carried out on trial fields and in pots.

It appeared that rooting is prevented by means of mechanical resistance when the pore volume is less than 40% of the total soil volume.
IMPORTANCE OF THE THEORETICAL CURVE OF pF ON SOIL WATER ECONOMICS

Miguel Cardoso Pereira Goes and Antonio Antunes da Silva

By using two points of the pF curve of several soils and by assuming its similarity to the right half Gauss curve, it was possible to arrive to a mathematical expression of the pF curve.

Tables are presented which show the experimental and the calculated data.

Some discrepancy was found among the calculated and observed values in the tail of low pF curve. By the way a tentative soil classification in relation to available water is presented, which may be important for the economics of water either under dry-farming or irrigated farming and for the control of holding capacity in soils.
ANALYSIS OF WATER-SOIL-PLANT RELATIONSHIPS

Robert M. Hagan and Y. Vaadia

Literature on water-soil-plant relations records many irrigation experiments supporting conclusions that seem diametrically opposed. Inadequate attention to the soil-plant environment as a whole, lack of sufficiently comprehensive and general working hypotheses relating soil moisture and plant growth, and limitations of present expressions for soil moisture availability all contribute to the conflicting reports. Disagreements arise from the empirical nature of conclusions as frequently drawn.

Optimal plant growth is dependent on adequate water supply. When transpiration losses are balanced by water absorption plant growth will not be limited by plant water deficits. When absorption lags behind transpiration, water deficits develop in the plant and may cause decreased growth. Water deficits are everyday occurrences in crop plants, but usually absorption at night offsets deficits produced during the day permitting recovery of turgor and continuance of what is recognized as normal growth. If the water deficit developed within the diurnal cycle is not restored during the night, then progressive decreases in growth should be observed.

Plant growth does not depend directly on soil moisture supply but rather on the balance between transpired and absorbed water. This balance is dependent on soil, plant and climatic factors. Prediction of plant water balance cannot be made from soil moisture data only nor can it be predicted from transpiration data alone. When transpiration demands are high, rate of water supply to and through plant roots likely limits plant water supply and thus determines its water balance and growth. However, under conditions of high transpiration demands, the plant water deficits may be negligible in one soil and considerable in another soil even at comparable suctions. This will depend on hydraulic conductivities of soil, on nature and distribution of root system in the two soils, and on other factors. Similar comparison could be made between two plant species differing in their ability to control water loss. If these two plant types are grown in the same soil under the same high transpiration demands, one plant may develop more serious moisture deficits than the other although both plant species absorb water at the same rates.

Determinations of soil moisture availability, based either on soil moisture contents as related to field capacity and wilting point or on soil moisture suction, cannot be expected, on theoretical grounds, to be an adequate basis for predicting plant growth. Relationships involving soil moisture content and/or soil moisture suctions and plant growth will be empirical and applicable to the crop under prevailing soil, climatic and management conditions. Such relationships cannot provide basic irrigation principles of wide application but rather furnish irrigation recommendations useful only in given situations.

Emphasis should be directed towards perfecting techniques for measuring plant water balance, studying flow characteristics of water in soil-plant-atmosphere continuum, and evaluating in detail the nature of the influence of plant water deficits on plant metabolism. Such information is necessary for development of valid and universally applicable relationships between plant growth and water.
ON A COMPLEX METHOD OF DETERMINING MOISTURE SURPLUS OR DEFICIENCY IN SOILS FOR PLANTS AND ITS USE IN AGRICULTURAL PRACTICE

A. M. Alpatjev

Year-to-year variable plant water-requirement is usually not taken into account when building drainage and irrigation systems. This leads to surplus, or deficiency of moisture in soils in certain years.

As a result of many years' trials, carried out under field conditions, the author recommends an indirect method of determining plant water-requirement under any geographical conditions in case of high yields.

Both yearly meteorological data and knowledge of yearly plant water-requirement allow to determine surplus, or deficiency of moisture in soils in given interphase time of plant development as well as in the whole growing period.

The essential of the offered method of determining plant water-requirement is to make good use of the so-called biological curve and data on the air moisture deficit. The biological curve shows the influence of the plant development rate on the expenditure of soil moisture whereas the air moisture deficit gives the influence of the current (or past) weather conditions.

The biological curve is found out experimentally by maintaining soil moisture not below 65-70% and not above 100% (peat soils excepted) of field moisture-holding capacity. This corresponds to the optimal moistening. Fig. 1 shows biological curves for barley and tomatoes (experiments having been carried out for 5 years) and potatoes (experiments - for 8 years).

Having mean biological curves for various plants as well as year-to-year data on precipitation, air moisture deficit and the store of soil moisture in spring it is possible to calculate moisture surplus, or deficiency within every field for any period of time. Without determining soil moisture one is able as well to prognosticate per decades the condition of water amount in the soil in a given year, data for regulating the work of drainage or irrigation systems having been used.

The method had been tested under field conditions for 8 years and in most cases errors have been stated by the author not to exceed 10-15%.

The method can be used for geographical investigations.
The effects of irrigation treatments on evapotranspiration and production of grain sorghum and wheat in the southern Great Plains

Marvin E. Jensen and Jack T. Musick

Experiments with irrigation treatments as the major variable were conducted at Garden City, Kansas, (Lat. 38°N) and Bushland, Texas, (Lat. 35°N) on grain sorghum and winter wheat from 1956 to 1959. The major grain sorghum producing area in the Great Plains is between the 30th and 40th parallel. The major hard red winter wheat area lies between the 32nd and 43rd parallel. Results obtained from these studies show that from 22 to 24 inches of evapotranspiration (ET) are required for maximum yields of grain sorghum with no significant difference in ET occurring between locations. For winter wheat, 22 to 29 inches of ET were required for maximum production. Approximately five inches more were required in Texas than Kansas. The lower ET in Kansas on winter wheat is primarily due to lower temperatures during winter months and early spring. Average July temperatures at these two locations are nearly identical, but January, February, and March temperatures are from 8° to 12° F. cooler in Kansas. Grain sorghum yields increased more rapidly than wheat yields with increasing irrigation levels, figure 1. The cumulative ET for these crops was similar at both locations except for winter wheat where a significant lag occurred in Kansas, figure 2. The quantity and distribution of rainfall greatly affected grain sorghum yields when seasonal ET was 19 inches or less. Maximum daily rates of evapotranspiration for 10-to-15 day periods ranged from 0.30 to 0.35 inches per day for wheat and grain sorghum at both locations. These rates occurred during the early fruiting stages of growth. Soil moisture stress during these stages of growth greatly affected yields. Winter wheat can tolerate less available soil moisture in the soil prior to irrigation without seriously affecting yields.

Fig. 1. The relationship between seasonal evapotranspiration and yield of grain sorghum and winter wheat in the High Plains of Kansas and Texas as affected by irrigation treatments, 1956-1959.

Fig. 2. Cumulative evapotranspiration for grain sorghum and winter wheat in the High Plains of Kansas and Texas with optimum irrigation, 1956-1959.
The rapid development of knowledge and understanding of water-soil-plant relations has resulted in an urgent need for a more precise, yet potentially more comprehensive system of terminology connected with the system. The choice of thermodynamic terminology to meet this need has several distinct advantages.

1. Water relations of soils and plants are thermodynamic in nature.
2. Movement of water through soils and plants has been attributed to thermodynamic forces.
3. Thermodynamic properties are readily observable and measurable.
4. The relations are basic and sufficiently flexible to allow for considerable development of the science by expanding the terminology.
5. Many of the water-soil-plant processes are energy dependent and temperature sensitive.

The free energy is the most useful thermodynamic property for expressing the condition of water in the multi-component soil-plant system. The Gibbs equation expresses the relation between the partial specific Gibbs free energy of water, $\Delta F_w$, and the measurable variables of temperature, $T$, pressure, $P$, mass fraction of water, $n_w$, and solutes, $n_j$, in the soil

$$\Delta F_w = -S_w \Delta T + \tau_w \Delta n_w + D \Delta \psi_w$$ (1)

where $-S_w = (\frac{2}{9} \Delta F_w P, n_w, n_j$ (the subscripts indicate that these variables are held constant) and is called partial specific entropy of water; $\psi_w = (\frac{2}{9} \Delta F_w T, n_w, n_j$ is the partial specific volume of water; $\tau_w = (\frac{2}{9} \Delta F_w P, T, n_j$ is called the moisture characteristic or retention curve; $D \Delta \psi_w = \sum_j (\frac{2}{9} \Delta F_w P, T, n_j$ dn_j and is called the osmotic component.

If the temperature is held constant at some reference temperature, and in the absence of an external force field the system is allowed to change from a state of pure free water at atmospheric pressure to some definite conditions in the soil-plant system, then equation (1) can be applied to the initial and final state to give

$$\Delta F_w = V_w AP + \int_1^{n_w} \psi_w \Delta T + \psi_w \Delta n_w + \int_0^{n_j} D \Delta \psi_w$$ (Ref. T) (2)

or schematically

$$\Psi = \psi_p + \psi_t + \psi_o$$ (Ref. T) (3)

The term $\Psi$ is defined as $\Delta F_w$ and is called the water potential, it is the difference between the partial specific Gibbs free energy of water in the system and water in the reference state; this term has been called total soil moisture stress (TSMS), capillary potential, $P_F$, diffusion pressure deficit (DPD), and suction force. The term $\psi_p = V_w AP$ is called the pressure potential of water in the system it is identical with turgor pressure or hydrostatic pressure. The term $\psi_t = \int_0^{n_w} \psi_w \Delta T + \psi_w \Delta n_w$ is called the matric (adjunct of matrix) potential because it expresses the affinity of the colloidal matrix that makes up the soil-plant system for water, this term is related to soil moisture tension or soil suction, it can be readily measured in both soils and plants. The last term $\psi_o = \sum_j D \psi_w$ is the osmotic potential because it is caused by the affinity of the dissolved solutes for water; this component has been called osmotic pressure in both soil and plant systems when it was expressed as equivalent pressure rather than as a potential energy. When other forces are operating other terms may be added.
CHEMISTRY OF SOIL ORGANIC MATTER

1. MICROMORPHOLOGIC AND CHEMICAL STUDY OF HUMUS FORMATION RESULTING FROM DIFFERENT VEGETAL SPECIES. Jose Maria Albareda

2. L'ENFOISSEMENT DIRECT DE LA TOURBE DANS LE SOL. P. Boischot - Mme Simon-Sylvestre

3. THE EFFECT OF PROLONGED CROP CULTIVATION ON DYNAMICS OF HUMUS NITROGEN, AND PHOSPHORUS IN SOILS OF THE SOUTHERN UKRAINE. A. M. Grinchenko and Ting Ruey Shing

4. EVOLUTION HEBDOMADAIRE DE L'AZOTE MINERAL EN SOL NU ET SOUS CULTURE PENDANT 2 ANNEES DANS LE NORD DE LA FRANCE. J. Hebert

5. ÜBER SALZE DER POLYACRYLSÄURE ALS MODELSUBSTANZEN DER STRUKTURBILDENDEN ORGANISCHEN BODENKOLLOIDE. A. Klimes-Szmik and I. Bodolay

6. THE BIOSYNTHESIS OF HUMIC SUBSTANCES AND THEIR TRANSFORMATION IN THE COURSE OF SOIL FORMATION. M. M. Kononova, I. V. Alexandrova, N. P. Belchikova


8. PHYSICO-CHEMICAL PROPERTIES OF A SOIL POLYSACCHARIDE. J. L. Mortensen

9. ZUR CHEMIE DER HUMINSÄURE-VORSTUFEN. W. Ziechmann

10. STUDIES ON THE OXIDATION OF THE ORGANIC MATTER OF THE Ao AND BH HORIZONS OF A PODZOL. M. Schnitzer and J. R. Wright

11. FUNCTIONAL GROUPS IN THE ORGANIC MATTER OF THE Ao AND B HORIZONS OF A PODZOL. J. R. Wright and M. Schnitzer

12. CHEMICAL STUDIES ON HUMIC ACID FROM A PODZOL SOIL. Alan Burges

13. THE COMPARATIVE RATES OF NITROGEN TRANSFORMATION IN SOME NATURAL AND SYNTHETIC ORGANIC MANURES. R. Hamissa and H. Hamdi
The increasing importance accorded to the influence of the mineral components in plants on the formation of the different soil types, and on their fertility, has led us to undertake an investigation in order to get a better understanding of the role played by the higher plants in this connection.

Different profiles of the Iberic Peninsula have been chosen, in which the predominant vegetation is represented by shrubs and tree species: Cistus Ladaniferus, Juniperus Nana, Buxus Sempervivens, Xarotammus Purgans, Corylus Avellana, Ilex Aquifolia, Quercus Lusitanica, Pinus Pinea, Pinus Pinnaster, Pinus Silvestris and Fagus Silvatica. Chemical and micromorphological studies have been carried out on these horizons.

In this investigation an effort has been made in order to elucidate:
1. The correlation between cation content in the vegetation and exchange cations in the profile.
2. The dynamics of the immediate principles (glucids, lypids and proteids), throughout the humic horizons.
3. The influence of vegetation on the pH values, on the fertilizing elements content, on the clay minerals formation (kaolinite, sericite, montmorillonite and beidellite types) and on the type of humus.

By using the Kubiena's techniques, a morphologic study of the humic horizons has been made in order to determine the decomposition stage of the vegetal material from the förna to the humic horizons already formed. The micromorphic preparations show the mineral and organic composition of the soil, the alteration stage of the organic compounds, specially cellulose, and also the fungi and microfauna population, which participate in the decomposition. The correlation between the chemical and the micromorphologic studies has been established.
L'ENFOUSSEMENT DIRECT DE LA TOURBE DANS LE SOL

P. Boischot - Mme Simon-Sylvestre

Lorsqu'on enfoui dans le sol une matière organique fermentescible, il s'établit une concurrence pour l'azote entre les plantes qui sont cultivées et les microorganismes qui décomposent cette matière organique.

Si cet azote est en quantité insuffisante on constate un effet dépressif sur la végétation. Si la matière organique est elle-même riche en azote et de décomposition rapide, elle fournit elle-même l'azote nécessaire et l'effet dépressif n'a pas lieu. C'est le cas des légumineuses employées comme engrais verts.

Si au contraire, la matière organique est pauvre en azote on est obligé d'ajouter un engrais azoté pour fournir aux microbes et aux plantes la quantité de N suffisante.

Dans le cas de matières organiques à décomposition lente (sciure de bois - lignine) l'effet dépressif est faible la première année de l'enfouissement, mais se manifeste les années suivantes et ce n'est qu'à partir de la 4e ou 5e année que l'action bénéfique de la matière humique formée se fait sentir.

En ce qui concerne la tourbe nous n'avons pas enregistré d'effet dépressif ni d'augmentation de rendement dû à la formation d'humus dans une expérience de 6 ans.

Il semble donc qu'au point de vue pratique la tourbe se décompose trop lentement pour pouvoir, malgré sa richesse en azote, être considérée dans un temps raisonnable comme une source d'humus.

Dans certains cas cette passivité de la tourbe semble être contredite par des émeutes rapides de température en tas.

Mais c'est là un phénomène exceptionnel qui n'a lieu que lorsque se trouvent mélangés à la tourbe des matières fraîches (racines végétales de surface ou matières ajoutées comme dans les composts) qui peuvent fermenter, mais cela n'a rien à voir avec la décomposition de la tourbe elle-même.

En tas, avec ou sans addition d'azote, comme cela se fait pour le fumier artificiel de paille, nous n'avons jamais obtenu de fermentation importante de la tourbe elle-même.

Pourtant in vitro et dans des conditions favorables exemple à l'étuve à 30° l'on constate un dégagement de CO₂ preuve d'une fermentation.

Mais celle-ci est très faible, nous avons constaté que dans les meilleures conditions nous n'obtenons en 100 jours qu'une perte de 1,2 p. 1.000 de carbone ce qui est faible.

Si nous avons à faire à des tourbes très humides, ce qui se passe dans la pratique, nous obtenons des chiffres beaucoup plus faibles de l'ordre de 0,05 p. 1.000 comme perte de carbone. Donc négligeables au point de vue pratique.

Moyen de stimuler la fermentation de la tourbe. Cette passivité de la tourbe peut être due à la formation de substances spéciales inhibant le développement microbien.

Il peut être dû également à un manque de matières nutritives.

Les essais faits en ajoutant à la tourbe tous les éléments nutritifs sauf le carbone et l'azote, montrent que dans ces conditions l'on peut augmenter la vitesse de fermentation.

Les essais faits in vitro et en tas ont été satisfaisants.

Reste à préciser dans quelles conditions ces apports peuvent être faits lors des enfouissements de la paille dans le sol.

La tourbe est une matière première de grande valeur, étant donné son état physique et sa richesse relativement élevée en azote, et il y aurait un grand intérêt à trouver le moyen de la transformer en humus stable dans les sols de culture.
THE EFFECT OF PROLONGED CROP CULTIVATION ON DYNAMICS OF HUMUS
NITROGEN, AND PHOSPHORUS IN SOILS OF THE SOUTHERN UKRAINE

A. M. Grinchenko and Ting Ruey Shing

The study of soil fertility dynamics resulting from the cultivation of a crop provides an important basis for rational utilization of land and raising soil productivity.

In view of this, we have studied the changes of the basic fertility elements caused by cultivation in the dark-chestnut soil of Ascania-Nova, Kherson Region of the Ukraine.

The soil on the test plots is a dark-chestnut, slightly alkaline, clay in texture, on loess.

The data collected show that ploughing the virgin steppe brings about radical changes in the properties and nutrition regime of the soil.

In the first years after ploughing the virgin land the organic matter under fallow rotation system gets mineralized rather fast in the surface horizon (0-12 cm) resulting in a marked decrease in humus content. In the subsequent prolonged cultivation period the humus content practically remains unchanged.

Periodical sowings under the grass rotation system of perennial alfalfa in arid-steppe does not produce any effect on the accumulation of organic matter (humus).

The study of hydrolyzed nitrogen (according to Tyurin and Kononova) shows that the available nitrogen content in the upper ploughed layers is much greater than in the lower horizons. With the increase of cultivation age the hydrolyzed nitrogen content in the soil under the fallow rotation system grows.

The investigation of the phosphate regime shows that the upper ploughed horizon contains much more mobile phosphates soluble in $\text{H}_2\text{O}+\text{H}_2\text{CO}_3$ than in the lower horizons. The soil under fallow rotation system contains more readily-soluble phosphates.

Consequently, the ploughing of virgin soils and effects of cultivation in the ploughed layer mobilizes the soil phosphates raising the degree of their availability.

The content of the phosphates soluble in 0.5 N of CH$_3$COOH was greater at the beginning of ploughing, in the course of prolonged cultivation the amount of the phosphates of that group decreased. In the soil under the grass rotation system the amount of the phosphates of that group was 2-3 times less as compared with the virgin soil.

As to the effects of ploughing the virgin land upon the phosphorus content fixed in its organic matter, the data obtained on the whole coincide with the changes in humus content.

It follows from the data obtained that grassland farming on steppe dark-chestnut soil results in a considerable decrease in phosphorus assimilation. In view of this application of phosphorus fertilizers to leguminous grass under the grass rotation system is very important in the improvement of nutrient regime and increasing the crop capacity.
EVOLUTION HEBDOMADAIRE DE L'AZOTE MINERAL EN SOL NU ET SOUS CULTURE PENDANT 2 ANNEES DANS LE NORD DE LA FRANCE

J. Hebert

Sur un sable limoneux tres profond, soumis a une rotation Betterave-Blé, on opère les prélèvements a des dates rapprochées (1 semaine) et fixes (conditions climatiques quelconques) dans les tranches 0-5-15-30-45-60. Les déterminations sont faites le plus rapidement possible après prélèvements (1/2 journée) sur le sol humide. L'azote minéralisable (suivant DROUINEAU) et l'humidité sont suivis. L'erreur statistique est de l'ordre de ± 6%.

1° - Les variations de l'azote minéral s'opèrent par des oscillations extrêmement rapides (éventuellement 1 journée) et importantes (30% ou plus). Ces variations affectent en mème temps la surface et la profondeur. Elles sont considérées comme des variations d'intensité du turn-over sous le climat considéré. L'estimation de l'azote minéral à une époque donnée est meilleure par des prélèvements répétés dans le temps que par un plus grand nombre de prélèvements effectués le même jour.

2° - L'azote minéral présente un minimum en Février. Il augmente brusquement en mars. En présence d'apports normaux d'engrais et des travaux habituels, la minéralisation présente des différences attribuables aux travaux propres à chaque culture. Néanmoins, le maximum d'azote est le mème dans les deux parcelles. Déduction faite des apports d'engrais, les quantités minéralisées semblent être constantes pour ce sol (80 Kg/Ha soit 7% de N total). En l'absence de drainage, peuvent se manifester des dépresseions de l'Azoite minéral, correspondant à des reconversions sous l'effet de facteurs climatiques complexes. L'azote ammoniacal est très faible au cours de l'été, avec, néanmoins de brusques pointes fugaces.

3° - L'azote minéralisable présente des oscillations aussi brusques et beaucoup plus importantes que celles de l'azote minéral, mais autour d'une position moyenne constante, peut-être caractéristique de la terre étudiée. Les variations sont en général de mème importance en sol nu et sous culture.

4° - La somme (N de la culture en cours de végétation + N minéral du sol) est équivalente à la quantité trouvée en sol nu (aux modifications près des variations temporaires). L'étude de la variation d'azote minéral en différents points diversement éloignés de la plante permettrait d'apprécier l'intensité des fournitures d'azote à un moment donné.

5° - Au cours de l'automne et de l'hiver, la diminution progressive de l'azote minéral est toujours accompagnée d'oscillations brutales, de mème importance que pendant les autres saisons. Il n'y a donc pas alors de modifications essentielles du turn-over. L'azote ammoniacal tend a augmenter. Sous ce climat, l'action microbienne n'est pas un facteur important de conservation de l'azote. L'évaluation de l'azote présent au printemps sur 1 mètre semble moins bonne que l'évaluation de l'azote d'automne et la prise en considération du drainage, en vue de déterminer les quantités susceptibles de participer à l'alimentation des récoltes.
ÜBER SALZE DER POLYACRYSÄURE ALS MODELSUBSTANZEN DER STRUKTURBILDENDEN ORGANISCHEN BODENKOLLOIDE

A. Klimes-Szmik and I. Bodolay


Die Ausbildung der wasserbeständigen, krümeligen Bodenstruktur ist demnach, laut der Ergebnisse unserer bisherigen Untersuchungen als Endergebnis besonders verwickelter kolloidchemischer Prozesse zu betrachten, wobei einerseits sich unmittelbare Wechselwirkungen zwischen den anorganischen und organischen Bodenkoloiden und andererseits die Bildung von organischen Niederschlägen mit zweibwertigen Metallkationen geltend machen.

Unsere Ergebnisse geben Richtlinien für die Praxis der Bodenbearbeitung und Düngung, wie auch zur Erhöhung der Effektivität der zur Bodenkrümelstabilisierung angewandten hochmolekularen Linearkolloide Kunststoffe des Polyacrylsäure Typs.
THE BIOSYNTHESIS OF HUMIC SUBSTANCES AND THEIR TRANSFORMATION IN THE COURSE OF SOIL FORMATION

M. M. Kononova, I. V. Alexandrova, N. P. Belchikova

It has been established, that the soil humus substances are a complex mixture of compounds, whose principal components are polyphenols, protein substances, amino acids. As a result of their condensation the primary particles of humus substances are formed. We have made an attempt to find out the way of the transformation of humus substances in the soil forming process.

Cultures of Aspergillus niger and Penicillium (Sp.) served as bio-tests. These may form humic substances in liquid medium, containing mineral salts and sugar. Proteins, amino acids, phenols (mostly as catechol substances), detected in the cultural medium, served as "structural units" of the newly formed humus substances. These as well as the soil humic and fulvic acids (isolated from chernozem and podzolic soils) are heterogeneous. This was shown on paper circular chromatograms (solvents n-butanol-acetic acid-water, 40:12:28), illuminated with UV rays. All humus substances formed several zones.

The characteristic features of the investigated substances were deduced from the data on the quantity of organic carbon, that moved from the central part of the chromatogram to the peripheral zones. The greatest amount of organic carbon moves to the peripheral zones in case of newly formed humus substances and fulvic acids; the least amount for humic acid isolated from chernozem. The humic acids from podzolic soils occupy an intermediate position.

Due to the fact that the solution of n-butanol-acetic acid-water has an acid reaction (pH = 5.2) these data enable one to say that all humus substances contain acid soluble and acid non-soluble fractions; the ratio of these fractions varies in different objects. The "maturity" of humus substances in the soil formation process is conjoined with the reduction of acid-soluble fraction. The most "mature" acids are the humic acids isolated from the chernozem soils; the "youngest" ones are the fulvic acids.

The data of extinction coefficient /E/, which was measured in humus substances eluated from different zones confirms this.
EXTRACTION AND CHARACTERIZATION OF ORGANIC MATTER OF A PODZOL B HORIZON

D. E. Coffin, W. A. DeLong and B. P. Warkentin

The soil investigated was obtained from the B21 horizon of a well-drained sandy podzol under a deciduous forest canopy in which American Beech (Fagus grandifolia) is a major component.

Organic matter was separated by mechanical agitation of a system containing soil, water, benzene and 8-quinolinol, the aqueous phase being maintained at pH 6.0-6.5. Twelve successive extractions removed 75-80% of the organic matter of the soil, one-third of which was in the aqueous and two-thirds in the benzene phase. On addition of cellulose powder to the benzene phase the soil organic matter was adsorbed. Separation of the powder followed by equilibration with 8-quinolinol-chloroform solution released part of the organic matter, treatment of the powder with 0.1 N sodium carbonate released another organic fraction. The organic matter in the aqueous phase of the extraction system, after removal of quinolinol by extraction with chloroform, was separated into four fractions using lauryl pyridinium chloride as a precipitant. In this way the six fractions of soil organic matter were obtained.

An attempt to apply the Forsyth method for the fractionation of soluble organic matter to the solutions obtained from the two phases of the extraction system failed. Practically all of the organic matter was adsorbed by charcoal and could be released from the latter only by treatment with dilute NaOH solution.

Organic matter from the aqueous phase of the extraction system which was not precipitable by lauryl pyridinium chloride (this represented about 4% of the soil organic matter) contained 5.6% nitrogen and 16.6% carbohydrate (as determined by the anthrone method). No other fraction contained more than 1.5% carbohydrate. The nitrogen content of the organic matter extracted was 2%. The other five fractions of the extracted organic matter appeared to be largely aromatic in nature. Following alkali fusion of the individual fractions, 19 phenolic substances were separated chromatographically. Four of these substances were identified as m-hydroxybenzoic, p-hydroxybenzoic, 2,4-dihydroxy benzoic and 3,5-dihydroxy benzoic acids respectively. The amounts of these four substances obtained after fusion, and estimated colorimetrically following coupling with diazotized p-nitroaniline, amounted in sum, to 12% of the total organic matter content of the soil. The monohydroxy acids predominated in each fraction. Since the extracted fusion products were equivalent to 40 and 70% of the organic matter of the various fractions, it is concluded that the phenolic products obtained after fusion accounted for a very large part of the organic matter of this soil horizon.
Polysaccharides in Paulding clay were extracted with warm water, precipitated and reprecipitated several times with acetone, desalted on ion-exchange resins and by dialysis, precipitated finally with acetone and hydrolyzed. X-ray diffraction showed that the major inorganic contaminant of the polysaccharide before desalting was CaSO\textsubscript{4}. Ash content of the desalted preparation was 5.9% and spectrographic analysis indicated the presence of Fe, Mg, Al, Na and Si.

Elemental analysis of the preparation (ash free basis) showed the following: Carbon, 50.17%, hydrogen, 7.39%, oxygen, 38.61%, nitrogen, 2.02%, methoxyl, 1.86%. Infra-red spectra showed the presence of hydroxyl, ethyl, methyl, carboxyl and amide groups.

Paper chromatography and paper electrophoresis showed the presence of glucosamine, glucuronic acid, fucrose, rhamnose, ribose, glucose, mannose, galactose, xylose and arabinose in a hydrolysate of the polysaccharide preparation. Several ninhydrin positive spots were not identified.

Continuous flow paper electrophoresis showed the presence of a single major component having three distinct bands of uronic acid concentration. Free-boundary electrophoresis in a Tiselius cell indicated heterogeneity.

Titration curves, ultracentrifugation, diffusion and light scattering measurements were made to provide information on molecular size and shape.
Die Chemie der Huminsäuren sieht sich folgenden, z.Zt. direkt kaum zu überwindenden Schwierigkeiten gegenüber:

Uneinheitlichkeit der synthetischen Modellsubstanzen bzw. aus dem Boden gewonnenen natürlichen Präparate,

unkontrollierbare Reaktionsfähigkeit bestimmter Anteile des Huminstoffkomplexes,

Fehlen von Charakterisierungs-, Trenn- und Bestimmungsmethoden.

Jede dieser Fragen scheint einzeln - am Modell - durchaus lösbar, Ansätze sind jedenfalls vorhanden, aber eine abschließende Klärung dieser sich gegenseitig bedingenden und beeinflussenden Probleme an einem (natürlichen) Substrat dürfte nicht möglich sein.

Aus der Tatsache aber, daß zur Kenntnis der Huminstoffe im Boden und ihrer Bedeutung für das Pflanzenleben die Bearbeitung bestimmter Fragen, die mit den oben aufgeführten Problemen verknüpft sind, unumgänglich ist, ergibt sich notwendig zunächst die Bearbeitung von Ersatzoder Modellsubstanzen. D.h., Substanzen die es erlauben aus dem Komplex der Problemverflechtung am natürlichen Objekt, ein Einzelproblem herauszulösen und damit ihre Bearbeitung und Lösung ermöglichen. Es ist evident, daß ein Modell eine Lösung des Problems der Huminstoffe nicht ermöglichen kann und daß daher eine sog. "Modellfolge", also mehrere sinnvolle aufeinander abgestimmte Modelle eingesetzt werden müssen.

Die Frage des Reaktionsmechanismus, die Chemie der einleitenden Schritte der Humifizierung waren der erste Gegenstand der mit Modellen wirksam bearbeitet werden konnte.

Von Hydrochinon (für Brenzkatechin, Pyrogallol, Gallussäure, also bereits aromatischen Systemen gilt Entsprechendes), ausgehend, konnte der Radikalcharakter der einleitenden Schritte der Humifizierung nachgewiesen werden.

Von hier aus lassen sich zwanglose und plausible Annahmen machen über die ersten Reaktionsschritte, die zu den bekannten reaktiven Gruppen und dem allgemeinen physikalischen Verhalten der Huminsäuren führen.

Damit wird deutlich: die chemischen und physikalischen Eigenschaften von Huminsäuren werden bereits am Beginn des Humifizierungsprozesses, also in der Phase der Huminsäurevorstufen festgelegt. So wird die überragende Bedeutung dieses Anteils der Huminstoffe für den Humifizierungsprozeß klar: den Chemismus und das Naturvorganges bestimmen weitgehend diese Substanzen, die Vorstufen, während physikalische Effekte vornehmlich von den Huminsäuren ausgehen dürften. Schließlich läßt sich aus den experimentellen Befunden auch eine hinreichende Abgrenzung von Vorstufen und Huminsäuren geben:

Vorstufen sind reaktionsfähig, Huminsäuren nicht, jene wandern im elektrischen Feld (Papierelektrophorese) diese nicht. Im nahultraroten und ultraroten Spektralbereich unterscheiden sich die Spektrten beider Stoffgruppen ganz erheblich durch Bandenreichtum, Bandenausprägung und Untergrundabsorption. Die Reaktion mit stickstoffhaltigen Substanzen (z.B. Aminosäuren) erfolgt bei Vorstufen und Huminsäuren vollkommen anders.

Modellsubstanzen und Modellreaktionen sind nur ein methodisches Hilfsmittel, aber sie zeigen uns in welchem Umfange die vom natürlichen Objekt aufgegebenen Probleme lösbar sind. Die an den Modellen geschärfte Methode ist daher abschließend auf die natürlichen Huminstoffe anzuwenden.
Although it has long been recognized that organic matter plays an important role in the genesis of podzols, more information is needed on the chemical constitution of the organic materials moving through the Ae into the B horizon before the reactions and mechanisms involved can be worked out.

In order to throw some light on this situation, the organic matter of the Ao and Bh horizons of a podzol was oxidized under both alkaline and acidic conditions. Using a slight excess of alkaline permanganate, about 65% of the carbon of the Ao horizon was oxidized to CO$_2$, 23% to oxalic acid and 2% to acetic acid. The remaining 10% resisted oxidation to these products. Under the same conditions 92% of the carbon of the Bh horizon was oxidized to CO$_2$, 7% to oxalic acid and 1% to acetic acid. The use of lower ratios of permanganate to organic matter permitted the separation of intermediate low-molecular weight acids which were subsequently fractionated by solvent-solvent extraction, esterification, vacuum distillation and chromatographic techniques in order to isolate identifiable substances.

Oxidation with 1:1 nitric acid solution converted about 70% of the organic matter from both horizons to volatile substances, mainly CO$_2$. The oxidation product (residual material) of the Ao organic matter contained succinic, glutaric, adipic, benzene tetra- and penta-carboxylic and picric acids. In the oxidation product of the Bh organic matter only benzene tetra-, penta-carboxylic and picric acids were identified. The acids identified represented about 5% of the original organic matter of both materials.

The results suggest that, (a) the organic matter of the Bh contained more aromatic structures than that of the Ao horizon and (b) the organic matter of the Ao horizon contained alicyclic structures. The possible significance of the acids identified in the oxidation products obtained from both types of degradation with regard to the chemical structure of the organic matter of both horizons will be discussed.
FUNCTIONAL GROUPS IN THE ORGANIC MATTER OF THE Ao AND B HORIZONS OF A PODZOL

J. R. Wright and M. Schnitzer

The close connection between the movement of metals, particularly iron and aluminum, and that of organic matter in the development of Podzol soils has long been recognized. The mechanism involved remains obscure largely because little is known about the chemical constitution of the organic material(s) moving from the Ao through the A2 and into the B horizon of the profile. It seemed likely that the metal-organic matter reactions involved would depend primarily on the nature of the periphery of the organic matter 'molecule', i.e. on the kinds and numbers of functional groups attached to the 'carbon skeleton.'

This paper reports the progress made in a systematic study of the peripheral groups, particularly the oxygen-containing functional groups, of the organic matter of the Ao and Bh horizons of a Humus Podzol. The organic matter extracted from the Ao was higher in carbon, hydrogen and nitrogen but lower in sulphur and oxygen than that extracted from the Bh horizon. Compared with that of the Ao, the Bh organic matter was considerably more acidic due entirely to a higher carboxyl content.

The distribution of oxygen in functional groups (Table I) showed that all of the oxygen of the Bh organic matter could be accounted for in functional groups, whereas only 60% of the oxygen of the Ao organic matter was similarly distributed.

Table I

<table>
<thead>
<tr>
<th></th>
<th>O as COOH</th>
<th>O as OH</th>
<th>O as CO</th>
<th>O as CH₃O</th>
<th>O accounted for</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ao organic matter</td>
<td>0.14</td>
<td>0.15</td>
<td>0.28</td>
<td>0.02</td>
<td>0.59</td>
</tr>
<tr>
<td>Bh organic matter</td>
<td>0.60</td>
<td>0.18</td>
<td>0.23</td>
<td>0.01</td>
<td>1.02</td>
</tr>
</tbody>
</table>

The presence of the major oxygen-containing functional groups was confirmed by infrared spectroscopy.

Analytical acetylation in conjunction with other methods of functional group analysis was used to estimate alcoholic and phenolic hydroxyls, amino and sulphydryl groups.

The significance of the reactivity of these functional groups with metals in the formation of Podzol soils is discussed.
CHEMICAL STUDIES ON HUMIC ACID FROM A PODZOL SOIL

Alan Burges

A number of authors have reported the supposed separation of humic acid into distinct substances either by paper chromatography or paper electrophoresis. In such experiments the amounts of the different fractions obtained are usually too small to permit detailed chemical analysis.

In the present work continuous electrophoresis has been used to separate the fractions in sufficient quantities to allow further chemical and microbiological studies. The apparatus used consists of a perspex box 60 x 30 x 2 cm. filled with quartz sand carefully washed in chromic acid and sieved to obtain uniform particle size. A number of small partitions at the top and bottom of the box were fitted to ensure uniform movement of the buffer solution. A voltage of 10 V/cm. was maintained throughout the experiment. Continuous flow was maintained by a series of mercury filled pipettes coupled to nipples along the base of the box and having a common outflow for the mercury. The humic acid used was extracted by 50% lactic acid from the B₂ horizon of a humus podzol under pines. Successful separation into bands was obtained by running in borate buffer at pH 6.5. Investigations of the fractions obtained in the initial experiments failed to show any consistent differences in chemical properties or infra-red spectra between them. In attempts to purify the fractions further some of the major band fractions were run a second or a third time through the apparatus. With fractions taken from the fast moving bands which had been precipitated and dried the original separation into bands was again observed. This suggested that the presence of the bands was, at least in part, a function of precipitating and drying. This was confirmed as follows: 40 gm. of humic acid were run through the apparatus and separated into fractions. The fast running and the slow running band fractions were each halved and one half run again immediately without precipitation; each ran as a fairly distinct single band in the same position as the original band from which the fraction had been collected. The other halves of the fractions were precipitated and dried. They were then redissolved in buffer and again run. The material from the fast moving band reproduced the original clear cut separation into bands and the quantitative amounts in the different bands corresponded well with the original separation. The material from the slow band showed some spread but no complete separation corresponding to the original.

It is suggested that the original fractionation was due to a separation of particle sizes rather than chemical entities. If the particles are precipitated and dried many of the smaller ones aggregate irreversibly to form larger particles and thus reproduce the heterogeneous distribution of particle sizes found in the original material. Precipitation and drying of the larger particles cause some fragmentation producing a small proportion of smaller particles but on the whole the larger particles are more stable. Supporting evidence that the separation is essentially into particle size groups has been obtained from light dispersion studies.

Similar results to the above have been obtained with commercial samples of humic acid prepared from coal.
THE COMPARATIVE RATES OF NITROGEN TRANSFORMATION IN SOME NATURAL AND SYNTHETIC ORGANIC MANURES

R. Hamissa and H. Hamdi

A controlled laboratory experiment was conducted to compare the rate of nitrogen transformation in ammonium sulphate with that of some natural and synthetic organic manures. The results can be summarized in the following:

Nitrogen transformation in the various organic manures was remarkably variable due to the differences in their chemical composition.

The organic manures used in the experiment can be divided into three groups as far as their rate of mineralization is concerned.

1. Manures which are quickly mineralized such as urea
2. Those which are slowly transformed represented by farmyard manure.
3. The rest have a rate in between the aforementioned groups. This includes the organics in the following descending order: dried blood, cotton seed cake and green manure.

The most active phase of nitrogen transformation was after 15 days of incubation for the synthetic organics and after 30 days of incubation for the natural organics. Accordingly, it is possible to measure the availability of nitrogen in synthetic organics after 15 days incubation, and after 30 days incubation for the natural organics.

A positive correlation was found between the nitrogen content and the nitrogen released from the different organic manures.
FOREST FERTILIZATION

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   Carl Olof Tamm

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    L. Leyton
NUTRIENT UPTAKE AND GROWTH AFTER FOREST FERTILIZATION IN SWEDEN

Carl Olof Tamm

Plant nutrient supply has long been considered one of the major factors determining the forest yield and the forest regeneration in Sweden. Ever since Alund's wood ash applications on drained peatland (from 1910 on) and Hesselman's ammonium nitrate experiments in the twenties and thirties, fertilizer experiments have been laid out from time to time. It has been clearly demonstrated that nitrogen deficiency is widespread on mineral soils while drained peatlands may be deficient in both minerals and nitrogen; the supply of P and K often is a limiting factor.

Addition of nitrogen (as ammonium nitrate or other fertilizers) stimulates growth considerably on most sites with mineral soil. The application of large amounts of fertilizer solutions at regular intervals over a period of some years seems to be the most effective treatment. It has thus been possible to increase the growth-rate of poor spruce manifold. After a 10-year-period, however, most of the growth effect has faded away. Single applications of fertilizers; (e.g., 100 kgs of N per hectare) produce an effect that is shorter lasting yet.

Usually, addition of fertilizers to young saplings, too, improves the growth, but the results are not quite so consistent as those obtained after treatments of old stands. Apparently, other factors such as competition, root development, and water supply may here be of greater importance than direct nutrient supply. The nutrient mobilization on a cleared area, including the "green-manuring effect" of the felling, described by Romell, also implies that the nutrient supply often is relatively good in the case of young trees planted or naturally established after felling an old stand.

Some of the recent experiments have been observed by foliar analyses of needle samples collected each autumn. In a few cases the total amount of nutrients contained in the tree stand and the top soil, too, have been estimated. The object of the experiments was to study the disposal of the added nutrients and the extent to which the nutrients are utilized by the stand.

It has been found that relatively small amounts of the plant nutrients added are taken up by the trees. Evidently, a large portion of an applied soluble salt must be considered lost, even if some of the added ions may be consumed by soil microorganisms, or preserved by chemical fixation or absorption to colloids. In the case of phosphorus and lime a large portion of the quantities added can still be found in the top soil of the fertilized plots four to five years after the treatment.
EFFECT OF FERTILIZATION AND WEED CONTROL ON ESTABLISHMENT, SURVIVAL AND EARLY GROWTH OF SPRUCE PLANTATIONS

Donald P. White

The use of various fertilizer materials, planting techniques and weed control to overcome early check of spruce plantations was investigated on a variety of planting sites in Michigan. Species investigated included *Picea glauca* (Moench) Voss, *Picea abies* (L.) Karst, and *Picea pungens* Engelm. Materials used were urea, ureaformaldehyde, complete formulations with and without ureaform nitrogen, and several types of pelleted material with soluble and slowly soluble potash sources.

Graded spruce transplants were hand planted in small plots in a randomized block or Latin square design. Application was made as a surface band, in the hole and in liquid form. Site preparation treatments included plowing, rototilling and a triazine type of herbicide.

Measurements were made on survival, terminal growth, foliage color, root development, and nutrient uptake.

Application rates of more than 2 ounces of complete commercial type fertilizers at planting time significantly reduced survival. Hole placement of non-pelleted fertilizers was injurious even at rates of one ounce per tree. First year response of trees to pelleted fertilizer applied in the hole at planting time was minimal due to slow disintegration rate of pellets. Pelleted complete fertilizer formulations (9 gm. pellets) containing slowly soluble potash were non-toxic and resulted in improved growth in the second growing season.

Control of weed competition was considered to be highly beneficial in Michigan spruce plantations. Fertilization without weed control results in reduced effectiveness of soil amendments.

Furrow planting was superior to rototilled strips. Weed control 8 lbs. per acre of 50% wettable simazine at time of planting was rated superior for survival and growth. No foliage injury from use of simazine herbicide was observed at 8 pound or 16 pound per acre rate.
The results of the investigations of soils in virgin forests have confirmed the opinion that the nutrient economy of virgin forests has a sustained, enduring character. This sustenance is valid for all types of virgin forests and their soils.

The presented microscopic, chemical and physical soil investigations have given visible and statistical proof for the existence of a nutrient cycle within forest soil.

Thus the nutrient economy of a forest is based on two processes: the nutrient supply to maintain the rotation, the nutrient rotation to feed the forest.

The nutrient cycle of the forest embraces the following partial processes:

1. Physiological capture and lifting of substance by all members of the forest community;
2. Physiological accumulation of substance by accumulation of organic matter and by humification;
3. Hydrological transport and accumulation of substance (eluviation and deposition);
4. Transport, deposition and mixing of substance by soil organisms.

The hydrological transports of substance thus are inserted into the nutrient cycle to a degree related to the total amount of rotating nutrients. Therefore, the eluviation of the topsoil is limited by (1) physiological capacity of the forest, and (2) sorptive capacity of the soil. Thus a forest protects its topsoil from nutrient losses within these limits.

In virgin forest and well managed forest both physiological capacity of the forest community and sorptive capacity of soil reach a site-bound optimum. Each forest has the ability to bring so much of the nutrient capital into circulation and to keep it there as is determined by physiological capacity of the community and sorptive capacity of soil. The amount of soluble nutrients in the topsoil exceeding physiological capacity of forest and sorptive capacity of soil, is subject to progressive eluviation; where the subsoil is poor in nutrients an accumulation of nutrients in the topsoil takes place.

This basic regularity may be called "law of sustained nutrient economy of forest." This law explains also the generally known fact that virgin forests and well managed forests may reach a high productivity even on sites poor in nutrients, provided the other factors are optimum.

The partial processes of the nutrient cycle are independent in themselves; they may coincide temporarily and locally or occur separately, may increase, weaken or nullify their effects mutually. There exist correlations and reciprocal effects between these partial processes, influencing decisively the overall nutrient cycle. If one or several partial processes are disturbed the dynamic equilibrium within the cycle gets disturbed. Therefore one may summarize this as the "law of relationships within the nutrient cycle."

Furthermore, the investigations express that mode and range of effect and degree of efficiency of the above-mentioned partial processes cause the development of a soil profile characteristic for the site. Zones of physiological and hydrological depauperation or accumulation may form, whereby physiological and hydrological zones of influence may overlap. This regularity is called the "law of profile development in forest soil."
SOME EFFECTS OF FERTILIZERS ON LOBLOLLY PINE

T. E. Maki

Fertilizers were applied in March of three consecutive years (1951, 1952, and 1953) to planted loblolly pine in Durham County, North Carolina (latitude approx. 36°-15'N, longitude approx. 78°-50'W). The results reported here include nine years of observations on two plantations which were five and ten years old, respectively, when the first of the three annual applications of fertilizers was made. The main fertilizer treatments included factorial combinations of ammonium nitrate at 0, 80, and 160 lb. N per acre annually, with double superphosphate at 0, 40, and 80 lb. P₂O₅ per acre, both at a unit level of 40 lb. K₂O per acre.

Some eight hundred sample trees have been observed and measured in the two plantations, and in the older one, composition of the green foliage and the quantity and composition of annual litter fall have been determined.

Most of the observed differences in foliage composition, in litter quantity and composition, and in growth response are attributable to nitrogen application alone. For example, the N composition of the green needles collected in March and June of the first and third season of study showed the following differences between a treatment with no nitrogen in contrast to one receiving the heaviest N application:

<table>
<thead>
<tr>
<th>Fertilizer treatment</th>
<th>March</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 lb. per acre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N P K</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>0 80 40</td>
<td>1.06</td>
<td>1.18</td>
</tr>
<tr>
<td>160 80 40</td>
<td>1.08</td>
<td>1.69</td>
</tr>
</tbody>
</table>

The annual fall of needles (exclusive of twigs, bark, and other debris) for the same two treatments has varied up to more than a ton of dry matter per acre between years, but after the first year the needle fall has been consistently greater in the plots supplied with nitrogen, as indicated below:

Average Dry Weight of Annual Needle Fall of Loblolly Pine in Lb. per Acre by Years after Treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1st yr.</th>
<th>2nd yr.</th>
<th>3rd yr.</th>
<th>4th yr.</th>
<th>5th yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lb. per acre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N P K</td>
<td>lb.</td>
<td>lb.</td>
<td>lb.</td>
<td>lb.</td>
<td>lb.</td>
</tr>
<tr>
<td>0 80 40</td>
<td>3400</td>
<td>3720</td>
<td>3560</td>
<td>4380</td>
<td>3370</td>
</tr>
<tr>
<td>160 80 40</td>
<td>3200</td>
<td>4450</td>
<td>5000</td>
<td>5700</td>
<td>4540</td>
</tr>
</tbody>
</table>

In the treatments without nitrogen only about 2% of the fascicles have more than the normal 3 needles per fascicle, but in the heavily fertilized plots the proportion of fascicles with more than 3 needles has reached more than 20% in some sample trees, and needle length has averaged over an inch longer.

Both diameter and height growth have similarly shown response to nitrogen, although the average superiority of fertilized trees may not appear impressive. For the younger plantation, for example, the average diameters and heights by nitrogen levels at the end of the eighth growing season, unadjusted for possible initial differences between treatment, were as follows:

<table>
<thead>
<tr>
<th>Nitrogen level</th>
<th>Diameter at 4½ feet - inches</th>
<th>Total height - feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₀</td>
<td>5.04</td>
<td>33.8</td>
</tr>
<tr>
<td>N₁</td>
<td>5.38</td>
<td>37.2</td>
</tr>
<tr>
<td>N₂</td>
<td>5.53</td>
<td>36.0</td>
</tr>
</tbody>
</table>
ERTRAGS- UND NÄHRSTOFFUNTERSUCHUNGEN AN FORSTLICHEN DÜNGUNGS-
VERSUCHEN VON H. VATER AUS DEN JAHREN 1906 BIS 1912

H. J. Fiedler

In den Jahren 1902-1913 wurden von Herren Prof. Dr. Vater, dem da-
maligen Direktor des Institutes für Bodenkunde und Standortslehre der
Fakultät für Forstwirtschaft Tharandt, eine größere Anzahl von Versuchs-
flächen angelegt, um einen Einblick in die Beziehungen zwischen dem
Nährstoffgehalt der Boden und dem Wachstum forstlicher Kulturen zu gewin-
nen.

Die Versuchsfläche besteht aus 10 Feldern a 0.20 ha. Die auf einer
Parzelle durchgeführte Düngung im Herbst vor der Pflanzung erfolgte mit
4000 kg Thomasmehl (17.9% P₂O₅) und 1000 kg Kainit (13.7% K₂O)/ha. Der
Dünger wurde in den Pflanzstreifen ausgestreut. Eine 1920 durchgeführte
Versuchsauswertung zeigte, daß die völlige Streuentnahme das Wachstum
der Kiefern sicher geschädigt hatte und daß auch eine teilweise Streuent-
nahme sich ungünstig auswirkte.

Die 1959 erneut durchgeführte Auswertung der Versuchsfläche läßt er-
kennen, daß die schädigende Wirkung einer einmaligen Streuentnahme noch
nach rund 50 Jahren deutlich erkennbar ist. Dies kommt in den folgenden
Untersuchungsergebnissen zum Ausdruck:

1. Durch Bodenunterschiede innerhalb der Versuchsfläche (wachstums-
fördernde Schichten im Untergrund der pleistozänen Sande) werden in ein-
zellen Versuchsparzellen Wachstumsunterschiede hervorgerufen.

2. Die Bodenunterschiede zwischen den Versuchsparzellen wirken auf
das Wachstum der derzeitigen Bestände in gleicher Weise wie auf das der
Vorbestände.

3. Setzt man die Wachstumsgroßen der einzelnen Versuchsparzellen
im Verhältnis zu denen der jeweiligen Vorbestände, so läßt sich der in
beiden Generationen gleichsinnig wirkende Einfluß der Bodenunterschiede bis zu einem
gewissen Grade ausschalten.

4. Die Versuchsparzellen mit besseren Bodenverhältnissen wurden
durch teilweise oder völlige Streuentnahme weniger geschädigt als die mit
geringeren Böden.

5. Mit Hilfe der doppelten Varianzanalyse und des t-Tests konnte
in dem als lateinisches Quadrat angelegten Versuch eine gesicherte Diffe-
renz zwischen den Parzellen ohne Streuentnahme und den Parzellen mit Ent-
nahme der halben Streuauflage (P = 1.03%) und eine gut gesicherte Differenz
zwischen den Parzellen ohne Streuentnahme und den Parzellen mit Entnahme
der gesamten Streuauflage (P = 0.327%) nachgewiesen werden.

6. Zwischen der gedüngten Versuchsparzelle und den ungedüngten
nicht streugenutzten Parzellen besteht kein gesicherter Unterschied.

7. Die Bodenflora der Versuchsparzellen unterscheidet sich wie
folgt:

a. In den nicht streugenutzten Parzellen zeigen die Astmoose
Pleurocium schreberi und Hypnum cupr. eine höhere Dominanz und Abundanz
als in den Parzellen mit Entnahme der gesamten Streuauflage.

b. In den Parzellen mit Entnahme der gesamten Streuauflage ist
der Anteit von Calluna vulgaris und Flechten größer als in den nicht streu-
genutzten Parzellen.
POTASSIUM FERTILIZATION OF CONIFEROUS PLANTATIONS IN NEW YORK

S. O. Heiberg and Albert L. Leaf

This paper discusses the results of 32 years of treatments with organic and mineral fertilizers to a deep, sandy, glacial outwash soil (Hinckley series) at the Charles Lathrop Pack Forest in the southeastern Adirondack Region of New York State. This area with ca. 40 inches precipitation per annum supported mixtures of Pinus strobus (L.) and Tsuga canadensis (L.) Carr. with some Picea rubens Sarg. as dominant vegetation prior to 100 years of cultivation and grazing. The original podzol profile had been destroyed with only the B2 horizon recognizable and a distinct soil plow zone (Ap) developed from the long agricultural use.

The early experiments dealt with organic additions, starting with logging slash in 1928 to 30-year old Pinus strobus followed by a growth response.

A few years following establishment of coniferous plantations on an adjacent open area in 1928, growth retardation and needle chlorosis were observed. To alleviate these conditions logging slash and humus additions were initiated in 1935. The humus was composed of the H layer from a thick greasy mor under an old Pinus strobus - Tsuga canadensis stand. The source of the logging slash, i.e. from a highly productive or depleted site, and tree species composition, affects the value of the organic matter as a soil amendment. It was demonstrated that increased fertility rather than mulching effect caused the growth responses of Pinus resinosa (Ait.), Pinus strobus, Picea Glauca (Moench.) Voss., and Picea abies (L.) Karst plantations. The growth responses due to the organic matter additions are still strikingly evident to date.

Applications of mineral fertilizer salts began in 1937 to determine the nutrient deficiency or deficiencies corrected by the organic matter additions. First, a 5%N-10% P2O5-5%K2O fertilizer, applied broadcast at 500 lbs/A (550 Kg/ha.), resulted in a strong growth response of Pinus resinosa. Broadcast applications of CaO at 500 lbs/A (550 kg/ha.), NaNO3 at 300 lbs/A (330 kg/ha.), (NH4)2 SO4 at 100 lbs/A (110 Kg/ha.), Ca3 (PO4)2 at 200 lbs/A (220 kg/ha.) and KCl at 200 lbs/A (220 kg/ha.) as pure chemical salts in 1943 to Pinus resinosa plantations resulted in a strong lasting growth response to K only. This use of pure chemicals as fertilizing materials was repeated in 1946 with additional K2SO4 treatment at 200 lbs/A (220 kg/ha.), and the strong, lasting growth response of Pinus resinosa resulted only from K as KCl or K2SO4. Subsequent fertilization of plantations of Pinus strobus, Picea abies and Picea glauca on similar soil resulted in a pronounced response of all to K fertilization even at the end of one growing season and continuing to date.

Since 1948 various commercial fertilizers containing macro- and micro-nutrient elements, applied at different times and rates have been used, and in all cases a strong, lasting response has been only to K. Applications of elemental K from 25 to 150 lbs/A (27-165 kg/ha.) has resulted in continuing, lasting growth response of Pinus resinosa. The response to N and P have been nil, and Mg improved foliage color but increased growth only slightly.

K deficiency symptoms of coniferous species include general chlorosis, browning and shortening of needles, decrease in the number of years the needles persist on the tree, and decreased height and diameter growth. The severity of deficiency and degree of response to K fertilization is related to the nutritional requirements of different species. K deficiency occurs when the current year terminal foliage collected in autumn analyzes less than 0.34-30% K for Pinus resinosa and Pinus strobus, 0.21-0.13% K for Picea glauca and Picea abies.
DÜNGUNG VON WALDBÖDEN, DIE DURCH STREUENTNAHME, FRÜHERE LANDWIRTSCHAFTLICHE NUTZUNG ODER AUS ANDEREN GRÜNDAEN AN HUMUS VERARMT SIND

H. C. Wittich

MINERAL NUTRIENT DEFICIENCIES IN FOREST TREES

John Hacskaylo

A general review of the literature on deficiency symptoms in forest trees is presented.

Methods for studying the major and minor mineral nutrient deficiencies of seedlings under greenhouse conditions are described.

Data for white pine, Scotch pine, sweetgum and black locust, when grown on deficient mineral nutrient solutions, are presented. Visual foliar symptoms, growth in height and diameter, wet and dry weight production, and water requirement are presented in relation to the single deficient major or minor nutrient element of the experiments.
RECHERCHES SUR L'ACTION DE DIVERS TRAITEMENTS CHIMIQUES DE HUMUS BRUTS SUR LA NUTRITION ET LA CROISSANCE DES RESINEUX

Philippe Ducaufour

I. DISPOSITIF EXPERIMENTAL.
L'expérimentation a porté sur la germination et la croissance de Pin sylvestre (Pinus sylvestris) et d'Epicéa (Picea excelsa), sur Mor traités par différents moyens chimiques; les semis ont été effectués au printemps 1958 sur "bâches de semis", de 0,5 m² de surface, et de 0,30 m d'épaisseur; ils ont été repiqués sur place, à raison de 500 au m2, au printemps 1959; enfin, les plants ont été arrachés, mesurés, pesés et analysés, en novembre 1959.

Les quatre modalités de l'expérience, effectuées en double pour chaque espèce, sont les suivantes:

- T - témoin, Mor, pH 3,8 C/N 36.
- N - même humus neutralisé par injection NH₃ gazeux.
- E - même humus, enrichi par un engrais comprenant: 500 g de "scories" et 250 g de sulfate d'ammonium pour 100 kg d'humus.
- E+Ca - même traitement, mais l'humus est en outre neutralisé par apport de 1 kg de CO₃Ca pour 100 kg d'humus humide.

II. RESULTATS OBTENUS.
1° Evolution des humus traités.
Tous les humus, même les témoins, ont évolué, par baisse de C/N, élévation du pH et élévation de la teneur en bases échangeables. Le traitement à NH₃ gazeux, qui solubilise beaucoup de matière organique aussitôt après le traitement, ne laisse que des traces assez faibles après 2 ans: le pH est redescendu à 4,2, la matière organique soluble, et l'azote ammoniacal ont disparu. Le traitement E donne un pH 5, qui semble optimum; le traitement E+Ca élève le pH à 6,8 dans un cas, 7,1 dans l'autre, et favorise seul la formation d'acides humiques.

2° Reprise et croissance des plants.
La levée des semis a été optimale dans les modalités T et E, et mauvaise pour la modalité N; même observation pour la reprise au repiquage, la 2e année. En ce qui concerne la croissance des plants repiqués, l'Epicéa s'est montré plus sensible à l'action de l'engrais (E) que le Pin: sa croissance (en poids) a été plus que double par rapport à T. Le traitement à CO₃Ca s'est avéré nuisible, dans la mesure où la neutralité a été atteinte: la croissance est alors faible pour les deux espèces et les aiguilles sont jaunes.

3° Nutrition minérale des plants.
D'après les analyses foliaires, les semis d'Epicéa des humus témoins ont été légèrement carencés en N la 1ère année, mais non la 2e année, après repiquage. Dans la modalité N, les plants, Pin et Epicéa, ont accumulé la première année N et P en excès, qu'ils paraissent avoir utilisés la 2e année.

La teneur en calcium des aiguilles, déjà fortement augmentée en E par rapport à T, est multipliée par 2,5 dans la modalité E+Ca; lorsque le pH dépasse 7, elle induit une carence marquée en Mg, qui semble expliquer la chlorose et la faible croissance des plants.

Conclusion: Le traitement optimum des humus acides consiste dans un apport d'engrais équilibré, élevant peu le pH; la neutralisation par le calcium semble provoquer une carence en magnésium et freiner la croissance.
The objective of the study reported in this paper is to determine how soil nitrogen content is related to forest site quality as indicated by height measurements of dominant and codominant trees in the forest. Twenty four mature site trees of *Pinus ponderosa* were selected in typical forest situations throughout California over wide ranges of climate on several soil parent materials (granite, basalt, sedimentary rocks, peridotite, and alluvium). A soil profile was sampled under each site tree; each in a similar location relative to the tree, and each in uniform depth increments to 122cm. (48") where possible. Total nitrogen contents of the soil samples were determined and these were related to the site index of the tree at the location.

The site indices adjusted to age 300 years ranged from 20 meters to 64 meters (65' - 210'). Site index as a function of various expressions of the soil nitrogen content such as percent by weight of the fine earth fraction (<2mm,) for various soil depths, percent by volume of nitrogen for various soil depths, and total nitrogen content per unit area for the entire soil profile was evaluated. The most satisfactory general relationship was that between site index and total soil profile nitrogen content per unit area. The total profile nitrogen contents of the mineral soils ranged from 220 gms. to 1390 gms. per square meter to a depth of 122 cm. (1,960 - 12,350 pounds per acre). There is a positive exponential relationship between site index for *Pinus ponderosa* and total soil profile nitrogen content. This relationship is linear when site index is plotted as a function of the logarithm of total soil profile nitrogen content. The equations are developed for these relationships both for mineral soil nitrogen and for mineral soil plus leaf litter nitrogen contents. A comparison is made with data from an independent study of similar relationships for *Pinus radiata*.

The general conclusion is that total soil profile nitrogen content adjusted for rock content and bulk density differences is a useful common measure for relating site index to soil nitrogen on diverse soils in various climates for *Pinus ponderosa* and may be for other species as well. The utility of this relationship for the solution of problems of forest management and silviculture such as estimating nitrogen fertilization requirements and evaluating site quality changes resulting from various silvicultural treatments is discussed.
This paper summarizes ten years of research on the use of fertilizer materials on Northwest Conifers. Results from both greenhouse nutritional research and extensive field tests are given. Greenhouse work determined macro-elements essential to growth as well as levels of elements. Solution and sand culture techniques have been used successfully. Deficiency symptoms for various elements have been established, as well as elemental foliage levels in greenhouse grown material, especially for western red cedar. Greenhouse pot tests of forest soils, using several species of forest trees as well as other test plants have also been an integral part of the work. Some difficulty has been experienced in growing Douglas fir under greenhouse conditions, apparently relating to temperature and light requirements. Greenhouse pot tests as well as initial field plots indicated a nitrogen deficiency in many low site stands of Douglas fir.

Foliage sampling and analysis from natural Douglas fir stands showed a very marked seasonal fluctuation and a critical September nitrogen content of about 1 per cent in current years foliage. Soil analysis indicates a critical surface soil (0-6") nitrogen content of 0.10 per cent. Nitrogen application of from 50 to 200 pounds per acre to stands on these soil and with these foliage nitrogen contents have resulted in very marked growth responses.

Growth response results from a series of field plots are enumerated and presented under the following discussion topics:

a. radial growth
b. height growth
c. volume growth
d. crown development
e. color and vigor
f. seed production

Responses have been substantially the same in age classes from 10 to 80 years and with or without thinning.

Some results on the economics of applying nitrogen fertilizer to forest stands are also presented.
The restriction of forest tree planting in Britain largely to marginal sites has focussed attention on the need for fertilizer amendments to make up for widespread nutrient deficiencies limiting growth. Trials have revealed marked responses to phosphates on many sites, particularly on moorland peat soils, and often to nitrogenous fertilizers on heath soils. In the past, attention has been directed largely to fertilizing at the time of crop establishment; recently trials have been extended to pole stage crops. The need for guidance as to the nature and extent of the deficiencies limiting growth is stressed and the merits of foliar analysis as an alternative to soil analysis are discussed. Reference is made to investigations on young Japanese larch and Sitka spruce stands planted on a variety of soils in various parts of the country, and showing variable responses to fertilizer amendments. It has been found that growth can be closely related to the N P K status of the current foliage, and provided that interactions are taken into account, relationships common to all sites can be established. Almost 70 percent of the variation in larch growth can be accounted for in terms of the varying N P K status of the foliage; much of the remaining variation appears attributable to mean site temperature. The significance of these findings is discussed in relation to their application in practice.
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2. STUDIES ON QUANTITATIVE RELATIONSHIPS BETWEEN SOILS AND SOIL-FORMING FACTORS IN NORWEGIAN FORESTS. J. Låg
3. L'INFLUENCE DE LA COMPOSITION MINERALOGIQUE SUR LA FORMATION DES PODZOLS FERRIQUES, HUMO-FERRIQUES ET HUMIQUES. Fr. De Coninck and Jac. Laruelle
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11. DIE BODENGENETISCHEN EIGENSCHAFTEN DER BRAUNEN WALDBÜDEN IN UNGARN. P. Stefanovits
SPÄT-UND NACHEISZEITLICHE BODENENTWICKLUNGSSTADIEN ÄOLISCHER SUBSTRATE

Ernst Schönthal

Alle Böden weisen einen mehr oder weniger dunklen, sehr dichten A$_1$-Horizont von etwa 5 - 10 cm auf. Der Gehalt an organischer Substanz schwankt zwischen 0.3 und 1.0%. Das Maximum wird an Unterhängen und in Vertiefungen erreicht, also an Stellen mit ehemals stärkerer Durchfeuchtung und dichterer Vegetation. Der 0.10 - 0.25 m mächtige A$_2$-Horizont ist ebenfalls noch dicht und je nach dem Gehalt an organischer Substanz hell-bis dunkelgrau gefärbt. In beiden Horizonten finden sich als Merkmal einer wechselnden Durchfeuchtung schwarze, mürbe Fe-Konkretionen von 0.5 - 2 mm Ø. Der B-Horizont ist meist gleichmäßig braun gefärbt und verhältnismäßig hohlraumreich. Konkretionen kommen nur noch wenig vor. Die Grenze zwischen dem B- und dem kalkhaltigen C-Horizont greift taschenformig in den Untergrund ein. Ein Ca-Horizont ist örtlich nur schwach zu erkennen. Die Entkalkungstiefe beträgt in ebenen Lagen 0.5-0.6 m und an Hängen 0.3-0.4 m. Analytische Untersuchungen haben ergeben, daß die beiden A-Horizonte an Fe, Al und SiO$_2$ verarmt sind. Außerdem - und das ist bemerkenswert - hat bereits eine stärkere Ton-Durchschlämmung stattgefunden, was durch mikromorphologische Untersuchungen nachgewiesen werden konnte.

Die Bodenentwicklung hatte demnach im Verlauf von etwa 8600 Jahren unter einem Klima mit relativ niedrigen Temperaturen und geringen Niederschlägen bereits ein Stadium erreicht, das sich grundsätzlich nicht von demjenigen des heute in Europa weit verbreiteten "sol lessive" unterscheidet.


Die Untersuchungen erbrachten den Nachweis, daß die Grundanlage des "sol lessive", der für die heute niederlagsreicheren Landschaften mit Lößdeckung charakteristisch ist, bereits am Ende des Spätwürms vorhanden war. Im Postglazial vollzogen sich in diesem Boden je nach Klima und Vegetation verschiedene Prozesse (Lessivierung, Podsolierung, Pseudovergleyung und Regradation in Richtung der Braunerde). Klima und Vegetation des Spätwürms haben demnach eine weit größere Bedeutung für die Bodenentwicklung als bisher angenommen wurde. Die große pedogenetische Zäsur der letzten 20,000 Jahre fällt somit etwa mit der Wende Prähoreal - Boreal zusammen (ca. 8,500 Jahre vor heute).
STUDIES ON QUANTITATIVE RELATIONSHIPS BETWEEN SOILS AND SOIL-FORMING FACTORS IN NORWEGIAN FORESTS

J. Låg

Most sciences have developed steadily towards using numerical expressions of the properties or processes to be characterized. Roughly speaking, this applies to soil science, as well, although the pedological part of this subject has been lagging somewhat behind. This fact is to some extent attributable to the difficulties encountered in grading the soil-forming factors and their effects numerically.

On analyzing the 5 different groups of soil-forming factors, we find that only time can be characterized completely by a single number. For other factors, e.g. the climate, it is possible to operate with quantitative expressions, while others again are very difficult to characterize numerically. The problems are also complicated by the interaction between the soil-forming factors, and to some extent by the mutual reaction between these factors and the soils.

For soil-forming factors that are difficult to characterize by numbers, I have proposed to use scales of rank order. It has, for instance, been sought to characterize plant communities and properties of the mineral material by this method. An example of a rough grouping of the Norwegian forest vegetation is given by the rank order scale:

1) broad-leaved forest,
2) forest of Norway spruce, and
3) forest of Scots pine, and for ground cover vegetation:
   1) forest ground rich in grasses and herbs,
   2) forest ground rich in mosses with some herbs,
   3) forest ground rich in Vaccinium myrtillus with Dryopteris,
   5) forest ground rich in Vaccinium vitis-idaea,
   6) forest ground rich in Calluna vulgaris, and
   7) forest ground rich in lichens.

The parent material can in the same manner be classified according to increasing particle size, and increasing resistance against chemical weathering.

The effect of the different soil-forming factors seems to be most fruitfully studied in areas where essentially different soil types occur. With a numerical material collected in collaboration with the National Forest Survey as a basis, it has been sought to determine the influence of the different factors on the relative distribution of podzol and brown earth, respectively. Attempts have been made to study the effect of each individual factor while the other factors, as far as possible, are kept constant. The change in each individual factor, leading to the same displacement in the proportional area of these great soil groups, should thus have the same effect. In other words, it should be possible by this method to find the magnitude of the changes required for the different factors to balance each other. This working method may be said to have for its principle the quantitative expression of the effect of the soil-forming factors on the basis of mutual counterbalancing of the changes in each individual factor.

In Norway, where the soil-forming factors vary widely, the natural conditions should be comparatively favorable for an investigation of such quantitative relationships.

In the soil survey in the Norwegian forests a classification has been made by gradient of surface into the following groups: 0-10%, 10-20%, 20-33% and over 33%.
Les podzols de la région sablonneuse de la province d'Anvers (Basee Belgique) peuvent se subdiviser en trois groupes: 1. Les profils avec un horizon B ferrique (podzols ferriques); 2. Les profils avec un horizon B humo-ferrique et d'humus (podzols humo-ferriques); 3. Les profils avec un horizon B humique (podzols humiques)

Les caractéristiques de ces différents profils sont les suivants:

1. Les podzols ferriques se caractérisent par un horizon ferrique discontinu, formé de plages et de concrétions ferrugineuses indurées dans un matériau meuble. Ces plages et concrétions ferrugineuses se substituent à un horizon d'accumulation d'argile, en bandes, qui est en voie de désagrégation. La destruction de l'argile dans l'horizon d'accumulation va de pair avec une libération et une concentration des oxydes de fer libres, provoquant l'induration de ces parties non encore dissoutes.

2. Les podzols humo-ferriques sont caractérisés par la formation d'un horizon d'accumulation d'humus sus-jacent à l'horizon B ferrique mais également entre les plages et les concrétions. Des études minéralogiques et analytiques illustrent les divers stades de l'évolution d'un horizon B textural vers un horizon B ferrique à concrétions.

3. Dans les podzols humiques on peut souvent reconnaître deux horizons d'accumulation caractérisés par deux formes différentes de l'humus. Ces podzols humiques se forment:
   a. dans des matériaux pauvres en minéraux pouvant libérer le fer. Toutefois il semble y avoir eu une accumulation d'argile sous forme de bandes très minces et d'une couleur verdâtre (p.e 5 Y 5/2-6/2: Munsell Soil Color Charts). La dissolution de ces bandes laisse un matériau blanchâtre (p.e. 5 Y 6/2: Munsell Soil Color Charts) sans les moindres traces d'oxydes de fer. Dans cet horizon éluvial, formé par la dissolution de ses bandes, se forme un horizon illuvial d'humus.
   b. dans les matériaux, qui à l'origine étaient moins pauvres en fer, mais après dissolution complète des bandes d'accumulation d'argile,
   c. dans des matériaux riches en minéraux de fer, mais en milieu réduit.
TUNDRA SOILS OF ARCTIC ALASKA

L. A. Douglas and J. C. F. Tedrow

Tundra soil horizons have an erratic appearance but there is a degree of morphologic profile continuity ascribable to pedologic processes. Tundra soil is characterized as follows:

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Depth</th>
<th>Description - Acidic Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3-0 in.</td>
<td>Organic matter, partially decomposed, fibrous.</td>
</tr>
<tr>
<td>2</td>
<td>0-10</td>
<td>Dark yellowish brown* silt loam, mottled.</td>
</tr>
<tr>
<td>3</td>
<td>10-15</td>
<td>Olive brown silt loam, mottled. Permafrost present.</td>
</tr>
<tr>
<td>4</td>
<td>15-30</td>
<td>Olive brown silt loam, frozen, considerable organic staining and shreds of organic matter present.</td>
</tr>
<tr>
<td>5</td>
<td>30+</td>
<td>Frozen, grey silt loam, considerable ground ice.</td>
</tr>
</tbody>
</table>

*Very dark gray colors predominate in calcareous soils.

The soil is frozen some 8-10 months of the year and the depth of seasonal thaw approximates 1-2 feet. Soil temperatures seldom exceed 5°C. Morphology together with chemical and physical analyses are given for three tundra profiles from the Alaskan Arctic Slope. Silt loam textures dominate, although clays of bentonite deposits and sands are occasionally found. Most clay minerals are allogetic and include 2:1 layer silicates, with some kaolinite, montmorillonite and a 14A mineral. No evidence of clay translocation within profiles was found.

Tundra soils are normally acidic in the surface and the pH increases with depth. Base saturation is usually less than 50% at the surface (acidic profiles) and increases with depth. Extensive areas of calcareous soils are present (loess?). Conductivity values of saturation extracts usually vary between 0.5 and 1.5 millimhos. Adjacent unvegetated earthy material (frost boils, etc.) may have conductivity values as high as 20 millimhos on the surface.

High relative humidity and low evapotranspiration help produce wet tundra soils, but leaching is less than in soils of temperate regions of higher rainfall.

Organic matter is very high in the surface horizon and C:N ratios usually approximate 14-15:1. Organic matter has an erratic distribution in the mineral horizons, however, the concentration in horizon 4 is of special interest. C14 ages of 8,000 to 10,500 years were obtained from horizon 4 from three profiles. Horizon 4 represents the soil surface of the somewhat warmer than today climatic optimum, which Hopkins postulates occurred 8,000 to 9,000 years ago. Subsequent lower temperatures resulted in a decreased active layer thickness and the accumulation of ground ice in part of the former active layer. The growth of ice forced mineral materials, parent materials for horizons 2 and 3, up through the vegetational mat (horizon 4). This coupling of pedogenic and cold-environment processes is considered as a regional condition in the Alaskan Arctic Slope.

Arctic investigators generally agree that the process operating in tundra soils is one of low temperature gleization coupled with frost displacement. On the isolated sites having free internal drainage, Arctic Brown soils show varying degrees of embryonic podzolization, but this concept cannot be applied to tundra soils. If we examine the views of Liverovski, Gorodkov, Filatov, Kreida, Svatchov, Grijoriev as well as our own, the major differences of opinion concern semantics rather than processes.
THE PRINCIPLE OF MOBILIZATION AND IMMOBILIZATION OF IRON OXIDE IN SOILS
AND ITS APPLICATION TO EXPERIMENTAL PRODUCTION OF PODSOLIC SOIL PROFILES

Keizaburo Kawaguchi and Yoshiro Matsuo

The ratio of the amount of active iron oxides in a soil to the amount of mobilizing materials which perhaps consist of chelating agents and protective colloids, is an essential factor governing mobilization and immobilization of iron in the soil. Mobilizing materials must be derived from plant residues. In this report, a concept of "the ratio of the amount of mobilized constituent to the amount of mobilizing material" is proposed and explained by the following experiments.

1. The aspect of dispersion (mobilization) and flocculation (immobilization) of ferric hydroxide sol is observed under different ratios of the amount of ferric hydroxide to the amount of leaf extract in the solution.

2. Solubility of ferric oxides of both chemical reagent and soil constituent in dilute oxalic acid solution are determined under different ratios of iron to oxalic acid.

3. In column experiments, differently experimental soil profiles are produced from equally filled soil columns on which leaves of cypress are placed and leached with water. Experiments were carried out under the various ratios of amount of ferric oxide in soils to amount of leaves.

From these experiments, the following mechanism of movement of iron oxide in soils is strongly suggested.

1. At the first step of mobilization of active iron oxides, mobilizing materials in solutions are adsorbed on the active iron oxides. When the ratio of mobilizing material to iron oxides exceeds a certain limit iron is mobilized. This corresponds to the mechanism of eluviation of iron in A horizon of podsolic soils.

2. When the amount of mobilizing materials is relatively less than the amount of iron oxide, the latter is dissolved. In certain cases, however, the iron dissolved is adsorbed on the solid iron oxide added to the solution. This corresponds to the mechanism of accumulation of iron in B horizon.

Based on this concept a new classification of iron in solution is proposed.

Amounts of iron oxide extracted with dilute oxalic acid solutions from horizons of a soil developed on cherty material

<table>
<thead>
<tr>
<th>Soil horizon</th>
<th>A$_2$</th>
<th>B$_{21}$</th>
<th>B$_{22}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Fe$_2$O$_3$ in air dry</td>
<td>2.57%</td>
<td>6.75%</td>
<td>6.30%</td>
</tr>
<tr>
<td>Active Al$_2$O$_3$ in soil</td>
<td>1.11</td>
<td>2.49</td>
<td>3.14</td>
</tr>
<tr>
<td>Fe$_2$O$_3$ in Soil 1 g</td>
<td>48.0 µg/ml</td>
<td>92.2 µg/ml</td>
<td>55.3 µg/ml</td>
</tr>
<tr>
<td>Soil 2 g</td>
<td>61.0</td>
<td>69.2</td>
<td>33.1</td>
</tr>
<tr>
<td>Supernatant</td>
<td>68.3</td>
<td>33.8</td>
<td>15.3</td>
</tr>
<tr>
<td>liquid</td>
<td>54.7</td>
<td>18.6</td>
<td>11.2</td>
</tr>
<tr>
<td>Fe$_2$O$_3$ in supernatant liquid</td>
<td>46.9</td>
<td>26.9</td>
<td></td>
</tr>
</tbody>
</table>

1) Each amount of soil was added to 100 ml of 0.1 N oxalic acid. After incubating three days at 30° C, Fe$_2$O$_3$ in the supernatant liquid was determined.

2) Two grams of each soil was added to 100 ml of 0.1 N oxalic acid solution containing 34.0 µg/ml of Fe$_2$O$_3$ previously.
Gray Wooded soils have been mapped in the northern and western extremes of the Parkland regions and in the Forest regions of Alberta. The formation of Gray Wooded soils in the northern Parkland regions are attributed to the invasion of forest, primarily aspen poplar (Populus tremuloides) onto the grassland areas bringing about a degradation of Chernozeml soils. The processes are activated by the acidic decomposition products of the forest organic matter. The sequence of profile changes are believed to be Chernozeml → Degraded Black → Gray Wooded. In the Forest regions the Gray Wooded Soils are believed to be the result of forest establishment on glacial materials succeeding glaciation.

Climatic conditions for the regions are sub-humid with regional precipitation ranging from approximately 12 inches in the north to 18 inches in the south.

The five Gray Wooded soils included in this study were sampled in areas which were moderately well to well drained. The glacial till parent materials were largely derived from bedrock formations of different geological age. Morphologically the profiles are very similar. In general, these soils have an A00 horizon composed of raw leaf litter underlain by an A1 horizon of semi-decomposed organic materials. The depth of the organic layer seldom exceeds 2 to 3 inches. A thin A2 horizon (less than 2 inches thick) may be present, but is generally absent. A well developed platy eluviated horizon (A2) with a friable consistency occurs at depths varying from 1 to 5 inches. The color in the moist state varies from pale brown to light yellowish brown and in some cases the A2 may be subdivided into an upper pale brown A21 and a lower light yellowish brown A22 horizon. The horizon of illuviation (B) forms largely as the result of clay accumulation. The upper portion of the horizon has a fine to medium blocky structure and a firm consistency while the lower portion is medium to coarse blocky. Color generally varies from brown to yellowish brown. Transitional layers between the A and B and the B and C horizons are generally present. The C horizon is glacial till which usually has a basic reaction but may be acidic.

Analyses of the five Gray Wooded soils included in this study reflect similar genetic processes but do show variations in their stages of development.

The matted surface organic layers have high carbon-nitrogen ratios with reactions of approximately pH 6. Exchange acidity is relatively low. A well decomposed humus layer is absent or very thin.

The eluvial horizons have been depleted of a considerable portion of their clay minerals, especially montmorillonite which is the major mineral in the remaining fraction less than 0.2 microns in size. Feldspar weathering, although not severe, attains a maximum in these horizons. The data for the illuvial horizons show marked clay increase in the fraction less than 0.2 microns in size, the composition of which is primarily montmorillonite. Feldspars are only mildly weathered. The pH data for the soil profile express low quantities of exchange acidity found for the sola developed from calcareous parent materials and medium quantities from non-calcareous parent material. The major portion of exchange acidity may be attributed to aluminum adsorbed on the exchange complex.

The parent materials have similar clay mineral suites even though they were derived from bedrock formations of different age. Variations in pH data for the parent materials appear to have an insignificant influence of the genesis of the profile.
ÜBER DIE FRAGE DER MITTEL- UND SÜDÖSTEUROPÄISCHEN TSCHERNOSJOMBÖDEN

L. Szücs

Mitteleuropa ist bekanntlich durch äußerst variable Naturverhältnisse gekennzeichnet, die eine lange Skala der Entwicklung der verschiedenen zonalen, wie auch intrazonalen Böden ermöglichen.

Im geologischen Aufbau sind außer den altertümlichen Trümmergebirgen auch die jüngeren eurasischen Kettengebirgen mit den durch sie umgeschlossenen Becken, die ausgedehnten Ebenen und aufgefüllten Tiefländer.

Ihr Klima wird überwiegend durch den Übergang von ozeanischen zu kontinentalen Umständen gekennzeichnet. In ihrem östlichen Teil ist jedoch der kontinentale Charakter, und im südlichen Teil - auf den dem Mittelmeer naheliegenden Gebieten - die mediterrane Einwirkung bemerkbar.

Die besondere geographische Lage entwickelt binnen der großen Familie der Tschernosjomböden charakteristische Tschernosjomtypen. In Mitteleuropa sind wesentlich zwei gut trennbaren und definierbaren Tschernosjomtypen, die geeigneter Weise auch bestimmbare.


Außer der erwähnten Typen wurden auch die Untertypen bestimmt, wo bei die Bodenentwicklungsprozesse die gleichen waren. Nachdem jedoch infolge der unterschiedlichen geographischen Umständen sowohl die Morphologie wie auch die Dynamik der Profile voneinander abwichen, sind sie zweckdienlich, solche Böden in Untertypen einzuteilen.
Im Gebiet Mitteleuropas und zwar namentlich auf dem Gebiet der Tschechoslowakischen Republik sind auf Silikatmuttergesteinen terrestrische saure Böden reichlich verbreitet, die wie folgt geteilt werden:

<table>
<thead>
<tr>
<th>Bodentypen</th>
<th>Terrestrische saure Böden in Mitteleuropa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boden ohne vertikale Translokalation</td>
<td>R$_2$O$_3$+SiO$_2$</td>
</tr>
<tr>
<td>Humifikation im ganzen Bodenprofil</td>
<td></td>
</tr>
<tr>
<td>Humifikation des oberen Teiles des Profils</td>
<td></td>
</tr>
<tr>
<td>Böden mit vertikaler Translokalation</td>
<td></td>
</tr>
<tr>
<td>Translokalation</td>
<td>Fe$_2$O$_3$+Al$_2$O$_3$+SiO$_2$</td>
</tr>
<tr>
<td>Translokalation</td>
<td>Al$_2$O$_3$+SiO$_2$</td>
</tr>
<tr>
<td></td>
<td>Mitteleuropäische Podsolböden</td>
</tr>
</tbody>
</table>

Die Podsolböden entstehen durch den Podsolprozess, den die vertikale Verschiebung von R$_2$O$_3$, SiO$_2$ und Humus in die Bodenuntergrundschichten charakterisieren, so daß sich der obere ausgebleichte berarmte Horizont ($A_2$) und der untere angereicherte oder Akkumulationshorizont $B$ ausbildet. Die vertikale Translokalation der Bodenkomponenten verläuft in verschiedenen sauren Milieu und bei einer ungleichen Stufe der Bodentonzersetzung, also wie durch die eigene Podsolisation (Orthopodsolböden), so auch durch die sogenannte Illimerisation oder "lesivage"-Prozess (Parapodsolböden). Die Morphologie sowie physikalischen Eigenschaften der Ortho- sowie Parapodzolböden sind übereinstimmend.

Nach der geographischen Verbreitung sind die Podsolböden auf dem Gebiet der Tschechoslowakischen Republik in zwei selbständige und ausgeprägte Zonen eingeteilt:
1. Zone der Podsolböden auf Silikatgestein in Niederungs- und Hügellandgebieten (200-500 m Seehöhe).
2. Zone der Humuspodsolböden auf Silikatgestein in höheren Gebirgslagen (1000-1800 m Seehöhe).


Die Podsolböden auf Silikatmuttergesteinen: 1. Böden ohne vertikale Translokalation (R$_2$O$_3$+SiO$_2$), 2. Böden mit vertikaler Translokalation (Fe$_2$O$_3$+Al$_2$O$_3$+SiO$_2$), 3. Böden mit vertikaler Translokalation (Fe$_2$O$_3$+Al$_2$O$_3$+SiO$_2$), 4. Böden mit vertikaler Translokalation (Fe$_2$O$_3$+Al$_2$O$_3$+SiO$_2$), 5. Böden mit vertikaler Translokalation (Fe$_2$O$_3$+Al$_2$O$_3$+SiO$_2$), 6. Böden mit vertikaler Translokalation (Fe$_2$O$_3$+Al$_2$O$_3$+SiO$_2$).
THE CHIEF PROBLEMS AND THE MOST IMPORTANT RESULTS IN THE STUDY OF FOREST VEGETATION INFLUENCES UPON SOILS

S. V. Zonn

The study of the interaction between the forest vegetation and soils has been conducted along the following lines:

1. The influence of the soil upon the growth and productivity of forests.

2. The changes in soils under the influence of forest vegetation.

New methods for a more profound understanding of the interaction between the forest vegetation and soils are being elaborated. The biogeoeconotic method is widely used; with this aim forest biogeoeconotic stations have been organized in almost all zones.

The display of many biological properties of a forest species depends upon site conditions and soil especially. The forest species as well as other plants do not podzolize soils. As a result of their activity the cycle of ash elements and nitrogen gets more intensive and complicated, these elements are accumulated in the soil, humus substances and secondary clay minerals are formed. The display of forest vegetation properties depends upon the composition and structure of a forest biocoenosis.

The varied duration of leaching in the annual soil water regime and the composition of soil solutions are determined by the space changes in the thermal and water regimes of the atmosphere. This determines the intensity of decomposition and leaching of the ash elements and organic substance accumulation. The vegetation can only modify to some extent these processes by concentrating separate elements and formation of new complex organic substances.

When the descending flow weakens or changes to an ascending one or when the conditions for organic substance decomposition change, the podzolization of soils decreases or a new soil formation process begins. The influence of the organic substances of separate forest species upon soils may be traced by a slight increase in the mobility of humus and ash elements.

The composition of organic matter in forest litters, soils distribution, mass and depth of root system penetration, interrelations of roots in different forest species schemes and the quantity of yearly root remnants in various soils are studied.

The water regime of forest soils is investigated considering all sources of water income and expenditure. The gaseous regime, as to the output of CO₂ from the surface and its formation and accumulation in soils is studied.

Similar attention is attached to the study of seasonal (annual) dynamics of the soil processes and nutrient compounds.

Progress made in the afforestation of light-chestnut soils of very acid areas has shown the possibility to transform the very nature of arid regions.

The out-of-date, now historical, views dealing with the role of forest vegetation in soil formation have yielded to new conceptions envisaging the forest as a mighty factor in changing the nature of soils and determining the multivarious trends in soil evolution.
The chernozems of Armenia differ from the similar chernozems of the Ukrainian Steppes and the Russian plains in their origin. Dokuchaev proved that the chernozem with a great amount of organic matter originates from the steppe grass vegetation as a result of its decomposition.

Dokuchaev after thorough study of the chernozem concluded that the bog soils do not form chernozem, just as forest vegetation forms no chernozem. But in natural conditions of Armenia at the height of 1500-2000 m. above sea level in some mountain regions, chernozems have post bog and forest origin. In the chernozem regions of Armenia we have large areas of bog soils, which are located in the Lory-Steppe, Bassin of Sevanlake, Kirovakan and other parts of the republic.

In order to characterize the connection of chernozems with bog soil for example we consider only one profile (Kirovakan) beginning from peat-bog soil to chernozem, as follows:

17. Peat-bog Soil - the ground waters are at 0,10-0,12 m, bog vegetation (Moss, Carex diluta, Juncus lamp., Myosotis, Heliocharis pal., Calamagrostis).

18. Bog-meadow soil - the ground waters at 0,40-50 m, vegetation - Carex dil., Juncus, Heliocharis, Brunella vulg., Myosotis, Moss.

19. Meadow-slight boggy soil - the ground waters at 0,70 m, vegetation - Carex dil., Deschampsia caespit., Trifol. pratense, Phelem prat., Juncus.

20. Slightboggy chernozem - the ground waters at 1 m, vegetation - Agrostis alba, Festuca prat., Phelem, Trifol. spadic, Coronilla varia.

21. Chernozem (leached) - the ground waters are at 1,5 m, wheat and potatoes.

Under the latter chernozem at 1 1/2-2 m. we discovered a residue of Phragmites com., Carex gracilis and veins of Fe2O3. From the above mentioned Peat-bog soil (17) to chernozem (21) the amount of organic matter gradually decreased from 50 o/o to 10 o/o, pH increased from 6,6 to 7.4 and granular structure appeared.

In several mountain regions of Armenia forest soils transform into chernozems. Paleonthologic, archeologic and historical data show that in the past in Armenia there was much more forest land than at the present. We found numerous residues of the forest plants in buried forest soils under the chernozem.

For the investigation of transformation of forest soils into chernozems we considered only one profile from the forest soil to chernozem (Mikoyan region).

104. Brown-forest soil. Native forest vegetation consists of oak predominately. The thickness of humus horizon 0,30 m., nut structure, leached, no carbonate.

105. Chernozem (transitory from forest soil to chernozem). Native vegetation consisted of Stipa Stenophilila, Festuca sulcata, Poa nemoralis, Phelem pratense, Trifol. ambigum, thickness of the humus horizon is 0,50 m, horizon A - granular structure, B - nut structure, C - is similar to hor. C of preceding forest soil.


The above mentioned data show that the forest soils of several regions of Armenia transformed into chernozem, due to culture, carbonate content of parent rocks, steppe vegetation, granular structure, increase of humus and increase of the thickness of soil.


Um die verschiedenen Typen der ungarischen braunen Waldböden zu kennzeichnen, werden die Angaben von 6 Profilen dargestellt. Das Profil Sz.14 ist ein Tschernosjom-brauner Waldboden auf Loess; H.13 ein Braunkernboden aus Loess; H.21 ein sol brun lessive ebenfalls auf Loess; M 8,6 ein sol brun lessive auf Andesit; M.19 ein schwarzer podsoliert sol lessive auf Andesit und M.23 ein saurer, nicht podsolischer brauner Waldboden (sol brun acid) auf Hydroandesit.

HABEN WIR EIN KONZEPT FÜR EINE WISSENSCHAFT VON DER BODENBEARBEITUNG?

H. Frese

Wenn unsere Kenntnis von der Bearbeitung des Bodens eine Wissenschaft sein soll, müßten wir wissen

1. Wie die wichtigsten natürlichen Bodeneigenschaften (genetische, morphologische, physikalische, chemische und biologische), die durch die Bearbeitung beeinflußt werden, qualitativ und möglichst auch quantitativ bestimmt werden können;

2. Warum und wie sie durch Witterung, Bodenbearbeitung und deren Wechselwirkungen beeinflußt werden;

3. Welche Ansprüche bestimmte Früchte auf einem gegebenen Standort an diese Bodeneigenschaften stellen;

4. Wie einzelne, oder ein Komplex dieser Bodeneigenschaften für diesen Zweck gezielt verändert werden können.

Dies waren von jeher die Fragen, die der Landwirt (farmer) an den Ackerbauer (agronomist) stellt. Früher hat dieser alleine versucht, diese Fragen zu beantworten, so lange er noch eine Art von enzyklopädischem Wissen auf dem Gesamtgebiet der Wissenschaft und der Praxis des Ackerbaues haben konnte. Heute muß er die meisten dieser Fragen an die Spezialisten der verschiedenen Fachgebiete weitergeben, die sich zu einem weitverzweigten System entwickelt haben. Die Vertiefung des Wissens durch Spezialisierung hat aber auch zu einer gewissen Zersplitterung der Forschungsarbeit geführt. Hierin liegt eine nicht geringe Gefahr.

Auch heute noch stellt der Landwirt seine Fragen aus der Gesamtsicht seiner praktischen Arbeit und dort will er auch alle Antworten der Wissenschaft eingliedern können. Der einzelne Forscher an der Front seines Spezialgebietes hat aber meist keine unmittelbare Beziehung mehr zu dem Zentralpunkt, d.h. dem Acker des Bauern, von wo die Fragen ausgehen, an denen er arbeitet. Der stark differenzierten Analyse der Fragen, die vom Acker kommen und dort wieder zusammenlaufen, steht heute keine konsequente Synthese gegenüber. Schon im wissenschaftlichen Bereich fehlt vielfach der Generalist, der nicht nur die Arbeitsrichtung der Spezialisten mit zu steuern vermag, sondern vor allem in der Lage ist, ihre Ergebnisse in einer wissenschaftlichen Gesamtsicht zusammenzufassen und auf die Ebene des Landwirtes zu projizieren.


Kennzeichen naturwissenschaftlicher Gesetzmäßigkeiten ist, daß sie meßbar und unter vergleichbaren Bedingungen reproduzierbar sein müssen, und daß ihr Ablauf vorhersehbar werden kann. Wegen der Vielzahl der im Boden wirksamen Faktoren und der Dynamik der auf den Boden einwirkenden Kräfte ist aber dort das Erkennen und das methodische Erfassen einzelner Gesetzmäßigkeiten besonders erschwert. Eine Aussicht hierfür besteht nur dann, wenn eine sehr große Zahl von Forschungsergebnissen nach einheitlichen, mindestens aber nach vergleichbaren Systemen gewonnen, ge-
ordnet und ausgewertet werden kann.

Aus dem Blickwinkel der Bodenbearbeitung ist diese Forderung am notwendigsten für das Gebiet der Bodenphysik, weil
1. Jede Maßnahme der Bodenbearbeitung in erster Linie eine Veränderung physikalischer Bodeneigenschaften bedeutet,
2. Diese physikalischen Veränderungen zwangsläufig auch Änderungen chemischer und biologischer Vorgänge einleiten und
3. Auf dem Gebiet der Bodenphysik die stärkste Verwirrung der Methoden, der Maßstäbe und der Begriffe herrscht.

Nicht weniger wichtig erscheint aber auch, daß
1. Die bodengenetische und morphologische Forschung (insbesondere die Mikromorphologie) neben der Klassifizierung noch genauere Unterlagen zur Kennzeichnung ackeraulich wichtiger Bodeneigenschaften beisteuert, die sich aus der Bodenentwicklung ergeben;
2. Die Ergebnisse mineralogischer Forschungen stärker für die Deutung physikalischer Bodeneigenschaften herangezogen werden;
3. Auf dem Gebiet der Bodenchemie, der Bodenfruchtbarkeit und Pflanzenernährung genauere Vorstellungen darüber erarbeitet werden, wie weit physikalische Veränderungen durch die Bodenbearbeitung solche Prozesse beeinflussen, die Bodenfruchtbarkeit und Pflanzenernährung steuern;
4. Die strukturellen Voraussetzungen für die wichtigsten mikrobiologischen Vorgänge näher präzisiert werden.

Die Schwierigkeiten, zu einer besseren Vergleichbarkeit und damit zu einer Koordinierung der Ergebnisse zu kommen, sind groß und allgemein bekannt. Aber nur auf diesem Wege scheint es möglich, von der Analyse zu einer Synthese, aus der Spezialisierung wieder zu einer Generalisierung zu kommen, und erst dadurch die Ergebnisse einer vielfältigen Grundlagenforschung für die angewandte Forschung und die praktische Bewirtschaftung des Boden nutzbar zu machen.
NUTRIENT AVAILABILITY AS RELATED TO MOISTURE AND OTHER SOIL PHYSICAL FACTORS

1. THE RELATION OF PLANT GROWTH AND YIELD TO SOIL OXYGEN AVAILABILITY. A. E. Erickson and D. M. VanDoren

2. THE INFLUENCE OF MOISTURE AND TEMPERATURE ON PHOSPHORUS AND POTASSIUM AVAILABILITY. Stanley A. Barber

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THE RELATION OF PLANT GROWTH AND YIELD TO SOIL OXYGEN AVAILABILITY

A. E. Erickson and D. M. VanDoren

During periods of high moisture, especially in soils with limiting pore size distribution, soil oxygen may be limiting to plants. Because periods of oxygen deficiency are usually of short duration, they have often been overlooked or considered unimportant. This paper reports studies of the response of plants to available oxygen and of oxygen availability in field soils.

Plants were grown in the greenhouse at various levels of oxygen availability which were determined by the measurement of oxygen diffusion rate using the platinum microelectrode method of Lemon and Erickson. Growth response curves were obtained. These curves had threshold values below which seeds did not germinate or plants died. There was a response range where plant growth increased with increased oxygen diffusion rate. Once maximum growth was obtained the curve became level and there was no change in growth with increased oxygen diffusion rate. The minimum oxygen diffusion rate for maximum growth is referred to as the "minimum rate" and soils having an oxygen diffusion rate below this rate are considered as "oxygen deficient."

Oxygen diffusion studies on field soils showed that most soils were oxygen deficient only for relatively short periods which followed rains. It was found that the periods of oxygen deficiency after a given rain varied with the structural condition of the soil.

Since plants growing under field conditions do not usually live under conditions of uniform oxygen availability, greenhouse studies were performed which subjected plants to only one short period of oxygen deficiency. One day of oxygen deficiency under certain conditions had a marked effect on the growth and yield of crop plants. There was a difference in the response of plants depending on the kind of plant and the stage of growth of the plant when the deficiency occurred.

This principle, that periods of oxygen deficiency at critical times in the growth of plants have a marked effect on the growth and yield, has been tested on field plots with gratifying results and can be used to study structure and its effect on crop production.
THE INFLUENCE OF MOISTURE AND TEMPERATURE ON PHOSPHORUS AND POTASSIUM AVAILABILITY

Stanley A. Barber

The response of crops to added nutrients varies from year to year. This variation is particularly evident on permanent field fertility plots. Although the yield with adequate fertilization may remain rather constant, the yield where either phosphorus or potassium is omitted varies widely. An experiment at the Purdue Agronomy farm, Lafayette, Indiana, illustrates this variation. The data given in Table 1 indicate that response to both phosphorus and potassium varies widely from year to year and since they vary independently, they are apparently affected by different factors. The phosphorus and potassium content of the corn leaf where these respective nutrients are omitted indicates that there is a variation in the availability of these nutrients from the soil.

The rainfall during the growing season, June 1 to September 1, was related to the response of corn to potassium. When the rainfall was low or very high, the response was large. When it was in the range of 15 to 20 inches, the response was small. Since the availability is least at the extremes of rainfall, it is probably affected by two different factors.

Greenhouse experiments indicated that the release of non-exchangeable K to exchangeable K was moisture dependent.

The effect of the moisture and temperature of the soil prior to cropping on the availability of soil phosphorus was investigated in greenhouse experiments. Increasing temperature in the range -2°C to 23°C increased the availability of phosphorus as measured by a subsequent uniform temperature cropping experiment. Moisture levels below field capacity had no influence. Moisture levels in excess of field capacity apparently affect the status of iron in the soil which in turn affects phosphorus availability.

Table 1. The effect of seasonal rainfall on the response of corn to phosphorus and potassium at Lafayette, Indiana

<table>
<thead>
<tr>
<th>Year</th>
<th>Rainfall</th>
<th>Increase in yield from Potassium</th>
<th>Yield with adequate P &amp; K</th>
<th>Leaf content where the nutrient was not added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inches</td>
<td>%</td>
<td>%</td>
<td>Bu.</td>
<td>K</td>
</tr>
<tr>
<td>1952</td>
<td>12.86</td>
<td>23.0</td>
<td>11</td>
<td>78</td>
</tr>
<tr>
<td>1953</td>
<td>15.16</td>
<td>7.3</td>
<td>13</td>
<td>123</td>
</tr>
<tr>
<td>1954</td>
<td>10.76</td>
<td>33.4</td>
<td>27</td>
<td>106</td>
</tr>
<tr>
<td>1955</td>
<td>9.96</td>
<td>26.0</td>
<td>0</td>
<td>112</td>
</tr>
<tr>
<td>1956</td>
<td>7.91</td>
<td>43.0</td>
<td>8</td>
<td>130</td>
</tr>
<tr>
<td>1957</td>
<td>17.68</td>
<td>5.5</td>
<td>6</td>
<td>156</td>
</tr>
<tr>
<td>1958</td>
<td>25.73</td>
<td>52.2</td>
<td>11</td>
<td>140</td>
</tr>
<tr>
<td>1959</td>
<td>5.43</td>
<td>20.8</td>
<td>27</td>
<td>101</td>
</tr>
</tbody>
</table>

* No analyses made.
Experimental results comparing the effects of soil moisture upon the exchange of ions from the soil to a synthetic cation exchange resin sheet and the effect of moisture upon ion absorption by soybean plants of two and eight weeks of age are reported. Eight moisture levels, ranging from below the wilting percentage to saturation were established. Cation exchange to the resin sheet was measured after a ninety-six hour exchange period. The soybeans were grown in small soil cores for one week and then transplanted into soils with specific moisture and fertility levels; the respective fertilizers being tagged with radioisotopes of Ca$^{45}$, Rb$^{86}$, F$^{19}$, and Fe$^{59}$. Uptake was measured after a ten day growing period. A similar procedure was used in growing older plants; the transplant-cores being larger and the plants were grown for six weeks before transplanting. The uptake was measured over a two week period. Uptake was measured by radioactive analysis of the plant material.

The data offer a comparison of the effects of soil moisture upon the exchange of Ca and K from the soil to a resin sheet surface on the one hand, and on the other, the combined effects of moisture on the exchange of ions to plant roots plus the indirect effects of moisture upon the metabolic processes of the root governing ion absorption. Decreasing the moisture reduced the exchange of Ca and K to the resin sheets in a linear relationship, the effect being more pronounced in the coarse textured than in the fine textured soil. The reduction in exchange, compared to that exchanged at the moisture equivalent, was 65% and 14% respectively, for the Ruston and Sharkey soil at the wilting point. Moisture reductions resulted in a greater decrease in the uptake of Ca and K from the coarse than from the fine textured soil. The reduction in uptake was greater for the plants than for the resin sheets. Similar effects were evident for the 2- and 8-week-old plants grown in the Ruston soil, the absorption of Ca and K being reduced by 95% at the wilting percentage.

The effect of moisture was not as great for the 2-week-old plants grown in the Sharkey clay; however, absorption by the 8-week-old plants was drastically affected by reducing the moisture to the wilting point. Nutrient uptake was correlated with the transpirational loss of water. The absorption of ions increased as transpiration increased up to the moisture equivalent, where ion absorption per gram of water transpired began to decrease and continued to do so to the saturation point. The largest amount of any one ion absorbed per gram of water transpired occurred at or near the moisture equivalent, with the smallest amount of uptake per gram of water transpired occurring at the wilting percentage and at the saturation point. The relationship was more pronounced for K and P than for Ca and Fe and also more evident in the coarse textured than in the fine textured soils.

Increasing moisture levels resulted in increased root growth. However the increased growth was not sufficient to entirely explain the large increase in ion absorption at the higher moisture levels. Likewise, the additional top growth did not explain entirely the additional uptake of ions, since increasing the moisture also increased the ion uptake on a percentage basis; the relationships being very similar to those for the total uptake of ions. Data relating the effect of moisture upon nitrogen uptake by cotton will be reported in the final paper.
Field studies relating nutrient uptake by plants to the soil moisture content present some experimental complications. These problems may be resolved, in part, by short-term uptake experiments in the laboratory with soil at a known moisture tension. As a result the controlling factors can be more accurately evaluated.

Phosphorus uptake using $^{32}$P as a tracer was measured in relation to soil moisture content on four soils ranging in texture from a fine sandy loam to a clay. Corn root seedlings with radicles about one inch in length were placed in aerated boxes containing soil at a predetermined moisture tension. Uptake of phosphorus was measured after a 24-hour absorption period.

The uptake of phosphorus by the roots decreased about threefold on all four soils as the moisture tension increased from $1/3$ to $9$ atmospheres. Data for the relative uptake of P (average of four soils) are shown in table 1. When uptake of phosphorus is plotted against moisture content of a given soil, the points fall on a straight line. Another related factor was the moisture content of the roots which decreased from $960$ to $630$ percent over the range of moisture tensions shown in table 1. Thus, some dehydration of the cell tissues took place, pointing to possible physiological effects on the roots.

Thickness of moisture films and diffusion path length of the ions appeared to be the major factors controlling P uptake in relation to moisture tensions.

Table 1. Phosphorus uptake by corn seedlings as related to soil moisture tension

<table>
<thead>
<tr>
<th>Moisture tension, atm.</th>
<th>Relative uptake of P</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1/3$</td>
<td>100</td>
</tr>
<tr>
<td>$1/2$</td>
<td>94.0</td>
</tr>
<tr>
<td>$1$</td>
<td>78.5</td>
</tr>
<tr>
<td>$3$</td>
<td>50.0</td>
</tr>
<tr>
<td>$9$</td>
<td>34.5</td>
</tr>
</tbody>
</table>

Phosphorus uptake was linearly related to the logarithm of the P concentration in water extracts (measured at a constant CO$_2$ pressure of 0.044 atmosphere and a soil:water ratio of 1:5) at a given moisture tension. Data are shown in table 2 for $1/2$ and $3$ atmospheres of moisture tension. The two higher levels of soluble P correspond to levels of available phosphorus in these soils such that little yield response would be observed from further additions of phosphorus fertilizer to plants in field experiments.

Table 2. Relationship between P uptake and P concentration in a water extract at two moisture tension levels

<table>
<thead>
<tr>
<th>Soil type</th>
<th>P conc. $M \times 10^6$</th>
<th>P uptake, mg. per g. roots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1/2$ atm.</td>
<td>$3$ atm.</td>
</tr>
<tr>
<td>Orman cl.</td>
<td>4.3</td>
<td>.0072</td>
</tr>
<tr>
<td>Pierre cl.</td>
<td>5.3</td>
<td>.0111</td>
</tr>
<tr>
<td>Apishapa si. cl. 1.</td>
<td>10.8</td>
<td>.0196</td>
</tr>
<tr>
<td>Tucumcari f. sa. 1.</td>
<td>18.5</td>
<td>.0268</td>
</tr>
</tbody>
</table>
DER EINFLUSS DER WASSERVERSORGUNG AUF DIE NÄHRSTOFFAUFNAHME DER PFLANZEN

K. Nehrling

Ausgehend von der Tatsache, daß die Auswirkungen klimatischer Faktoren in großen Regionen, aber auch innerhalb abgegrenzter Gebiete teilweise von Jahr zu Jahr stark unterschiedlich sein können, wurde die Frage untersucht, wie sich verschiedene hohe Niederschlagsmengen bzw. verschiedene Wasserversorgung auf die Qualität der Ernteprodukte, insbesondere aber auch auf die Nährstoffaufnahme und auf den Mineralstoffgehalt auswirken.


Die analytischen Untersuchungen sind weiterhin auf verschiedene Micronährstoffe (Mn, Cu, Co) ausgedehnt worden. Auch hier zeigt sich, insbesondere beim Cu-Gehalt, eine Beeinflussung des Aneignungsvermögens durch die den Pflanzen zur Verfügung stehenden Wassermengen.

ION UPTAKE UNDER SYSTEMS OF MOISTURE STRESS AND MOISTURE CONTENT

D. B. Peters and M. B. Russell

The research of Danielson and Russell showed that uptake of Rubidium-86 was reduced by increasing soil moisture tension in soils, but that uptake was relatively unaffected by increasing osmotic stress in solution cultures. They hypothesized that the reduced uptake in soils was due to the reduction in diffusion rate of the ion species as moisture content was decreased. Wiersum, using an excised root technique, came to essentially the same conclusion.

Further research using the technique of Danielson has shown that the reduction in uptake is more closely related to the reduced concentration of the ion species than to reduced diffusion to the plant roots.

In figure 1 it is clearly shown that the concentration in plant roots is a function of the effective concentration of ions in the soil. The data in figure 1 represent a large number of combinations of moisture content and moisture tension.

Furthermore, the temperature dependence at any one effective concentration is too large to be accounted for by simple diffusion.

In addition, the reduction in ion uptake is strongly influenced by the growth rate in plant roots. Increased tension or reduced moisture content has large effects on the rate of growth of plant roots. This reduced growth rate in turn reduces the roots' ability to absorb ions.

The reduction in ion uptake with increased moisture stress is especially pronounced with phosphorus, rubidium, potassium, and minor element ions. The reduction is barely detectable with calcium and magnesium ions. Reduction in phosphorus uptake has been reported a large number of times in recent years in irrigation experiments.

![Graph showing concentration in corn roots as function of effective concentration in soil.](image)

**FIG. 1**—Concentration in corn roots as function of concentration in soil.

*BD = BULK DENSITY

\( P_w = \text{PERCENT WATER} \)

\( M_{Rb} = \text{MOLALITY OF RbCl} \)
Studies of the relation between soil moisture content and the uptake of ions by plants are usually limited by lack of a technique for controlling or stabilizing soil moisture content within narrow and well defined limits while the plants are growing. The conventional method of subjecting the growing plants to various soil moisture regimes and allowing soil moisture to vary between field capacity and some lower limit is undesirable because of the oscillating nature of the regimes and because the plants may be subjected to internal water stress. This stress may affect rate of plant development and ion accumulation and obscure some of the more direct effects of soil moisture level on ion uptake.

This paper describes a split root technique designed to enable a portion of the plant to develop in soil with a previously adjusted moisture content which varies within narrow limits while the remainder of roots develop in sand wetted with nutrient solution. Figure 1 shows a diagram of the system. Corn seeds planted in the sand develop a root system in the sand that eventually passes through the wax membrane into the soil below. A tight seal is made at the point of penetration and prevents water from leaking from the sand into the soil below. No water is added to the soil during growth. The readily available water in the sand supplies most of the water transpired by the plant, insures against a growth limiting water stress within the plant and minimizes soil water depletion.

In experiments with the above technique a silt loam soil (moisture contents at 1/3 and 15 atmospheres were 25 and 6.4% by weight respectively) was adjusted to 7, 9, 11, 14 and 18% moisture by weight. Three levels of K (0, 37, and 75 ppm) were added to the soil at each moisture level and placed in the divided compartment container shown in figure 1. The sand system was wetted with a minus K nutrient solution. The system was kept in a constant temperature water bath from seeding to harvest. After 25 days growth the plants were harvested (roots excluded) and analyzed for K.

The data (Fig. 2) show increasing potassium content in the corn tissue with increasing soil moisture at all levels of added K. The response to moisture level varied with the quantity of K added. At the zero level of K addition the response was curvilinear while at second and third levels of K the curves appear to have inflection point at about 10% moisture. Total K data (not shown) show a similar trend.

In view of these and supporting data, high soil moisture tension or low soil moisture content may limit plant development by significantly reducing K accumulation when soil K levels are low. At high soil K levels plant K concentration may vary with soil moisture, but so long as the plant K variation is within the optimum range growth may not be affected by differences in accumulation.
PLANT GROWTH, ION UPTAKE, AND WATER CONSUMPTION AS FUNCTIONS OF INTERACTING ACTIVITIES OF WATER AND IONS UNDER SALINE-SODIC CONDITIONS

J. V. Lagerwerff and Gen Ogata

Previous studies (cf. USDA, Handbook 60) dealing with an analysis of the factors affecting yield and mineral composition of salt-injured crop plants indicated the necessity to distinguish between the total salt level or salinity, and specific-ion effects, particularly as related to the relative proportion of sodium ions with respect to calcium and magnesium ions, expressed as the sodium-adsorption-ratio, Na⁺/√Ca⁺⁺ + Mg⁺⁺, umoles 1/2 liter⁻¹/2, of the saturation extract.

It is of importance to gather knowledge on the interactive influence of the salinity and the sodium-adsorption-ratio on the plants grown, i.e. to investigate whether the tolerance with respect to salinity depends on the concentration (activity) of Na⁺ present in the substrate, or the tolerance with respect to sodium on the salinity. In addition, in considering the problem of salt-affected agriculture, the question arises as to whether the growth depression of the plants is related to the physico-chemical activity of the water in the root environment, which decreases as the salinity increases, or whether there occurs, solely or in conjunction, a direct adverse effect due to an excess of ions entering the plant system.

In order to study the latter point, a comparison has been made in terms of plant growth between isotonic solutions, the activity of the water of which had been diminished either by the addition of electrolytes, or by the addition of both electrolytes and non-electrolytes. Ideally, one should select a type of non-electrolyte inert with respect to the metabolism of the plant system. Using dwarf red kidney beans as a test crop, a high-molecular weight plastic compound was found that satisfactorily approximated this goal. Subsequently, solution culture studies were initiated, the experimental design of which provided for two osmotic levels brought about by the solution in water either of electrolytes alone, or of the plastic compound in addition to electrolytes. At the same time, at each of the osmotic levels two values were established for the sodium-adsorption-ratio, thus allowing for the opportunity to study the interaction between these variables with respect to plant growth and ion uptake.

Except for Na, Ca, and Mg, added as the chlorides, all other macro-, and micro-nutrients required for a complete nutrient solution were present as non-variables in properly balanced proportions. Yield, mineral composition, and consumptive use of water by the plants were related to the activity of water and ions. Throughout these investigations the osmotic level of the solutions, and the activity of the water, were determined by measuring the aqueous water vapor pressure using a technique recently developed at this Laboratory (Science 128:109).

With regard to the salt tolerance of dwarf red kidney bean plants, the experimental results indicated that the degrees of salinity-tolerance and sodium-tolerance are quantitatively interdependent. As to the consumptive use of water, it appeared that the uptake per unit weight of leaf strongly increases when the level of salinity and sodium of the nutrient solutions is raised. Thus, the activity of water was not found to be positively correlated with the rate of water-uptake by the plants. Finally, under the experimental conditions observed, indications were that beyond a total salt concentration of the ionic environment of the roots, the growth depression due to osmotic effects is augmented by that due to specific-ion effects.
COMMISSION II-V - Session I

Room B - August 22, p.m.

PHYSICAL CHEMISTRY AND SOIL FORMATION

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3. CHARGE DISTRIBUTION AS A CRITERION FOR CLASSIFICATION OF SOME
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4. SOILS OF THE KENYA HIGHLANDS IN RELATION TO LAND FORMS. James
   Thorp and E. Bellis

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9. MINERALOGY OF A SOIL FORMED FROM EOCENE 'SANDSTONE'. L. E.
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10. THE STUDY OF CLAY ON SOME GENETICAL SOIL TYPES IN YUGOSLAVIA. A.
    Skorić

11. PHYSIOOCHEMICAL CONDITIONS IN KRASNOZEM FORMATION. S. N. Aleshin
INFLUENCE OF THE DEGREE OF CALCIUM SATURATION AND THE REDOX STATE ON THE RETENTION OF NUTRIENTS IN SOILS

L. Wiklander

To show the effect of the degree of Ca saturation of soil and clays on the exchangeability of other adsorbed cations the following experiments were performed.

A cultivated clay soil (pH 4.9, humus content 5.0%) was limed to pH 6.1 and 7.2 by addition of CaO. The three soil samples were fertilized with appropriate amounts, containing also Sr^90. Water was added to maximal water capacity and equilibrium solution removed by suction. The soil samples were then leached slowly, until three successive 1-litre-portions were obtained. The solutions were analyzed for Ca, Mg, Sr, K, Na, Mn, Cu, Fe, Cl, S, and F.

From the experimental data only those of Sr, Mg, and K are summarized:

<table>
<thead>
<tr>
<th>Sr</th>
<th>Mg</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg/l</td>
<td>m.e./l</td>
<td>m.e./l</td>
</tr>
<tr>
<td>pH of soil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.9</td>
<td>6.1</td>
<td>7.2</td>
</tr>
<tr>
<td>Equilibrium soln.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.3</td>
<td>17.8</td>
<td>14.6</td>
</tr>
<tr>
<td>1st leachate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.8</td>
<td>6.6</td>
<td>5.5</td>
</tr>
<tr>
<td>2nd &quot;</td>
<td>0.45</td>
<td>0.55</td>
</tr>
<tr>
<td>3rd &quot;</td>
<td>0.32</td>
<td>0.66</td>
</tr>
</tbody>
</table>

These data show that increasing Ca/H of soil leads to lower concentration of Sr, Mg, and K in the equilibrium solution. During leaching, however, the picture is reversed and the retention decreases with increasing Ca saturation of the soil. The other cations, except for Ca, behave the same way.

This surprising change of the relation between Ca/H and adsorption of other cations has been studied by an additional experiment with both topsoil and subsoil. It was likely that this phenomenon could be caused by a gradual change of the redox state of the soil during the leaching.

Two series were arranged, one of which was kept in contact with air and the other with nitrogen gas. After 13 days the redox potentials in the soil suspensions were determined and the equilibrium solutions removed and analyzed.

The results from this experiment were similar to those of the previous one. In the aerobic series the adsorption of cations increased with the degree of Ca saturation but in the anaerobic series from the top layer the adsorption decreased with increasing Ca saturation. In the subsoil, poor in humus, there was no significant difference between aerobic and anaerobic series: in both liming increased the retention of cations.

These results indicate that the influence of the redox state on the relation between retention of cations and degree of Ca saturation is primarily due to reaction occurring in the organic matter. Where no such reactions take place liming of soils of this kind leads to a stronger adsorption and better retention of cations against leaching. Also pot experiments have given evidences of this statement.
Routine techniques for determining pertinent charge characteristics of soils have been developed. These consist of measuring negative charges with BaCl$_2$-triethanolamine at pH 8.2 and positive charges with H$_3$PO$_4$ of a base saturated soil at the established equilibrium pH. Newly developed charges of the phosphated soil were also determined with BaCl$_2$-TEA. These delta (CEC$_m$-CEC) values were taken to represent a portion of the total positive charge. The charge characteristics were then divided as follows:

1. CEC$_m$-CEC = me% "NPC," net positive charges; attributed mainly to sesquioxide hydrates.
2. AEC-"NPC" x 2 = me% "CNPC," combined negative - positive charges; attributed mainly to 1:1 lattice minerals and amorphous, allophane-like materials.
3. CEC-(AEC-"NPC") = me% "NNC," net negative charges; attributed mainly to 2:1 lattice minerals, amorphous eolian clays and humates.

The percentage charge distribution was then obtained by dividing the sum of items 1, 2 and 3 into each respective charge and multiplied by 100. The percentages found were then rounded to the nearest unit of 10 and recorded as "charge distribution class" in the order: net negative combined and net positive, viz. 5:3:2 indicates approximately 50% net negative, 30% combined and 20% net positive charges. On this basis a total of 66 combinations were possible.

The Routine methods also included determination of permanent charge (CEC$_p$) by means of a neutral salt (KCl or BaCl$_2$) and variable charge (CEC$_v$) by means of BaCl$_2$-TEA. In addition exchangeable H$^+$ and Al$_3^+$ associated with CEC$_p$ and covalently bound H associated with CEC$_v$ were determined.

The significance of the data obtained by these procedures has been evaluated against models of clay minerals and soils adequately characterized by X-ray and DTA methods.

Application of the methods has been made in conjunction with soil classification, liming practices, phosphorus fixation and residual phosphorus effects on crop growth.
Charge distribution as a criterion for classification of some equatorial soils

Ted Miller and A. Mehlich

Charge characteristics of soils are essentially expressions of the predominant type of colloid. Humates, amorphous silicates and 2:1 lattice minerals exhibit largely net negative and sesquioxide hydrates largely net positive charges. Minerals of the 1:1 type and allophane-like materials exhibit both negative and positive charges. Hence, characterization of charge distribution in terms of net negative, combined and net positive would appear to be a promising criterion in soil classification.

The study of hundreds of soil profiles in Kenya showed a distinct interrelationship between charge distribution and morphological characteristics as observed in the field. These interrelationships were found useful and important in establishing the validity of field separations, and the reasons for certain differences between soil types.

Wide ranges in charge distribution in soils having strong differences in physical characteristics also indicated great differences in soil colloid classes. This is especially evident in comparisons between soils of unlike Great Soil Groups - such as between the Black Cotton Soils or Grumusols and the Latosols. But distinct differences also occurred between soils having only minor differences in observable physical properties such as is characteristic of many of the red soils of Equatorial areas. Charge distribution appears to be particularly useful in the classification of the very large and inclusive group of reddish soils known in recent years as Latosols. A valid basis for the separation of soils within this group may be indicated.

In virtually all of those soils examined, absence of clay skins was correlated with very low net negative and high combined charges while considerable occurrence of clay skins was correlated with considerable net negative charge. Likewise, soils derived from ferro-magnesium rocks showed a greater preponderance of net negative charges than those derived from silicious rocks, such as granite in which case combined charges predominated. Most of these reddish soils carried some net positive charge.
SOILS OF THE KENYA HIGHLANDS IN RELATION TO LAND FORMS

James Thorp and E. Bellis

The Kenya Highlands, 3,000 to 17,000 feet above sea level and astride the equator, comprise 75,000 square miles in British East Africa, centering around 0° latitude, 36° east longitude. The north-south Rift Valley, 20 to 40 miles wide, bisects the highlands. Peneplain remnants of probable early Cretaceous, early to middle Miocene, and Plio-Pleistocene ages and dissected in varying degrees, preserve remnants of soils of many different ages and degrees of weathering. Basic and intermediate volcanic rocks from early Miocene to Recent ages fill and border the Rift Valley. Beyond these, both to the east and west, ancient siliceous igneous and meta-sedimentary rocks dominate the scene.

Rainfall comes in either one or two well-defined rainy seasons in most of the country and the amount of rain is closely related to orography. Rainfall ranges from about 20 to perhaps 100 inches. Dry weather prevails between the rainy seasons. Temperatures are fairly high in lower areas, and moderate to frosty at higher altitudes.

Deep, red, friable soils characterize well-drained older surfaces in humid climates, "black-cotton" soils (grumusols) are typical of level to moderately sloping, subhumid, wet-dry areas where the surface of the land is no older than mid-Pliocene. Soils with laterite horizons are most extensive on old smooth plateau remnants, largely of Miocene age. Many youthful (late Pleistocene to Recent) soils on seepy lower slopes have horizons resembling ground-water laterite, but with many fresh minerals, especially feldspars, that came from recent volcanic eruptions.

Soils high in humus are most characteristic of cool highland forests, and of moors above timberline. Subhumid to semiarid regions have, in addition to grumusols, approximate equivalents of Chernozem, Chestnut and Brown soils, and more extensive associated Solonetz and Solod soils. These soils are on land surfaces dating from mid-Pliocene to Recent. A vast area of maximal solidized Solonetz or Solod occurs on the cool Kinangop Plateau - elevation circa 8,000 feet.

Catenary soil associations of several kinds are widespread in Kenya Highlands. Among the commonest are, from high to low positions:

1. Lithosols - "Reddish Prairie" (?) - Solidized Solonetz - Grumusol (periodically swampy).

"Pallid soils" of various sorts resemble somewhat Red-Yellow Podzolic soils, but formation of typical examples of the latter has been prevented by termite activity.

Most stone lines in Kenya soils seem to be largely the result of termite activity.
The process called alkalization of soils is of great importance in Hungary. One phase of this process consists in the destruction of the adsorbing complex. Due to the decomposition of colloids free iron oxides are formed in alkali soils, they move downward and are precipitated as gels in the B-horizon. The same changes take place in consequence of flood irrigation. Therefore it is necessary to investigate the movements of iron with respect to the alkalization as well as to the influence of irrigation on the soil. The author proved that in those soils, where degradation processes occur (e.g. alkalization or podzolization), and besides due to flood irrigation, the readily soluble iron content of the upper horizons increases. The movement of iron has been investigated for two years in the profiles of the following four soil types: meadow soil, sulfate-containing alkali soil (solonetz), flood-irrigated sulfate-containing alkali soil (solonetz), flood-irrigated sulfate-containing alkali soil, and flood-irrigated hydrocarbonate-containing alkali soil. The adjoined figure shows the changes of the readily soluble iron content in a sulfate-containing alkali soil and in a meadow soil in the course of one year. It is evident, that the amounts of readily soluble iron in the A-horizon of the alkali soil are all the time considerably greater than those in the corresponding horizon of the meadow soil.

Postulations arising from the dynamics of iron: There is a correlation between the translocation of iron and the intensity of the alkalizing process. A common factor, inducing both kinds of changes, is the moistening of the soil, that creates anaerobic conditions. Both processes display seasonally limited dynamics. The translocation of iron in the upper horizons forms a part in the alkalization process, while that in the lower horizons is correlated with the nature of the parent rock and with movements of the ground water. In alkali soils the movements of iron are greatly enhanced by flood irrigation. They are taking place more speedily and to a greater extent by flood irrigation than by natural factors. After cessation of irrigation, under the influence of crop rotations containing grass crops, and of soil reclamation, the movement of iron and the destruction of the colloid complexes are greatly slowed down in a year. It could be stated, that the cultivation of rice in the crop rotation intensifies the degradation process to a lesser extent than monocultural methods. The translocation of iron in sulfate-containing and bicarbonate-containing alkali soils takes place in a different manner. In the upper layer of sulfate-containing alkali soils the translocation of iron had been greatly intensified by August, in consequence of flood irrigation, while the same was the case in bicarbonate-containing alkali soils as late as October. In irrigated solonetz soils on which formerly rice has been grown, greater amounts of readily soluble iron are found, than in those which had been irrigated for a short period only. A close correlation exists between the translocation of iron and microbial processes.
DAS PROTONABGABE- UND PROTONAUFNAHMEVERMÖGEN EINIGER UNGARISCHER BODENTYPEN
Johann di Gleria

Protolytische Vorgänge, d.i. solche, in denen Protonen abgegeben oder aufgenommen werden, spielen in der Ausgestaltung der Bodenschnitte eine gewichtige Rolle. Im Boden finden protolytische Vorgänge statt einerseits zwischen der Oberfläche der Bodenteilchen und der Solvathülle derselben, bzw. der Bodenlösung, andererseits auch während der Zersetzung der im Boden vorhandenen Minerale, bzw. bei der Bildung neuer Minerale (Tonmineralen). Die nachstehenden Ausführungen beziehen sich nur auf die ersterwähnte Gruppe protolytischer Vorgänge.


Nimmt die Konzentration der Hydroniumionen (Wasserstoffionen) in der Bodenlösung zu, dann werden an den negativ geladenen Stellen der Teilchenoberfläche Protonen aufgenommen, demzufolge nimmt die Zahl der negativen Ladungen der Teilchen ab, ebenso auch ihre Kapazität für die Adsorption von Kationen. Im entgegengesetzten Fall gehen Protonen von der Teilchenoberfläche in die Bodenlösung über, die Zahl der negativen Ladungen auf der Oberfläche nimmt zu, und die Adsorptionskapazität des Bodens für Kationen wird erhöht.


EXCHANGEABLE CALCIUM AND ALUMINUM RELATIONSHIPS IN TROPICAL SOILS

Hugh Popono

During a study of shifting cultivation in the Polochic Valley, Guatemala, soils varying widely in ecology (elevation, rainfall, geology, soils, topography) were sampled. The results of chemical analyses revealed certain fundamental relationships regarding exchangeable cations:

1. Exchangeable aluminum was inversely related to exchangeable calcium.

2. Soil pH was directly related to exchangeable calcium and inversely related to exchangeable aluminum.

3. Though cation exchange capacity was directly related to organic matter, there was no obvious relationship between the exchangeable nutrient cations and exchange capacity or organic matter.

These relationships were quite evident and existed despite the fact that soils varied widely in pH, exchange capacity, organic matter, nutrients and clay minerals. A rough approximation of soil cation nutrient status for the Polochic Valley could be obtained from soil pH values, but apparently not from organic matter, exchange capacity or percent base saturation data.
Die Solonetz-Böden werden als karbonatfrei bezeichnet, wenn ihr A-Horizont keine wasserunlöslichen Erdalkalikarbonate enthält, an sorbiertem Natrium aber mehr oder weniger reich ist. Die in Frage kommenden Böden haben einen verdichteten und sehr wasserundurchlässigen B-Horizont, der an Erdalkalikarbonaten und sorbiertem Natrium reich ist.

Die Bildungsweise des A-Horizontes der genannten Solonetz-Böden ist noch nicht geklärt.

Im Laboratorium kann man einen Boden mit sorbiertem Natrium sättigen, wenn man ihn mit Lösungen neutraler Natriumsalze, zur Entfernung der Umtauschprodukte, dauernd durchwäscht.

Unter natürlichen Verhältnissen, insbesondere in Gebieten, in welchen karbonatfreie Solonetz-Böden verbreitet sind, ist aber eine derartige Durchwäsung in nennenswertem Grade unmöglich.

Bekanntlich ist das Soda (Na₂CO₃) eine sehr wirksame Reagenz, durch die sorbiertes Natrium im Boden angespeichert werden kann. Nach den neuesten Ansichten kommt diesem Salz die Hauptrolle bei der Solonetzbildung zu, zumal es unter anaeroben Verhältnissen aus Natriumsulfat gebildet werden kann:

\[
Na₂SO₄ + (C) \rightarrow Na₂S + CO₂
\]

\[
Na₂S + H₂O + CO₂ \rightarrow Na₂CO₃ + H₂S
\]

Wenn nun das Natriumkarbonat auf einen mit Erdalkalikationen (Ca und Mg) gesättigten Boden einwirkt, wird der Eintausch des Natriums unbedingt durch Bildung von Erdalkalikarbonaten begleitet:

\[
(Boden)Ca⁺ + Na₂CO₃ \rightarrow (Boden)Na⁺ + CaCO₃
\]

Es entsteht, also, ein karbonathaltiger Solonetz-Boden.

Es ist ein solcher karbonathaltiger Solonetz-Boden instande, auf irgendeinem Wege sich in einen karbonatfreien Solonetz-Boden umzuwandeln, d.h. ist es möglich die Erdalkalikarbonate aus der Bodenmasse zu entfernen, ohne das sorbierte Natrium mitzuentfernen? Bodenchemische Erwägungen beantworten diese Frage dahin, daß eine derartige Möglichkeit kaum anzunehmen wäre, weil alle Faktoren, die die Erdalkalikarbonate zu lösen vermögen, auch das sorbierte Natrium und zwar sogar schneller entfernen.

Mit der Kohlensäure z.B. verläuft zuerst folgende Reaktion:

\[
(Boden)Na⁺ + H₂CO₃ \rightarrow (Boden)H⁺ + NaHCO₃
\]

worauf das Auflösen des Kalziumkarbonats eintritt:

\[
CaCO₃ + H₂CO₃ \rightarrow Ca(HCO₃)₂
\]

Die Bildung des karbonatfreien A-Horizontes der Solonetz-Böden läßt sich ohne Weiteres durch die Annahme erklären, daß er vor der Sodalösung basengesättigt, sauer gewesen ist.

\[
(Boden)H⁺ + Na₂CO₃ \rightarrow (Boden)Na⁺ + H₂O + CO₂
\]

\[
(Boden)H⁺ + NaHCO₃ \rightarrow (Boden)Na⁺ + H₂O + CO₂
\]

Es darf also angenommen werden, daß die karbonatfreien Solonetz-Böden aus ehemaligen basengesättigten (sauen) Boden entstanden sind.

Es ware dies nämlich denkbar, wenn in Gebieten der sauren Böden der Grundwasserspiegel, infolge Änderung der hydrogeologischen Verhältnisse steigt, und das Grundwasser natrium sulfathaltig ist.

Diese Vorstellung über die Bildung der karbonatfreien Solonetz-Böden entspricht weitgehend den wichtigsten Eigentümlichkeiten dieser Böden, z.B. der Teilnahme des Natriums an der Kationenbelegung der Ko- loide, der morphologischen Beschaffenheit des Profils und der geographischen Verbreitung der in Frage kommenden Böden.
MINERALOGY OF A SOIL FORMED FROM EOCENE 'SANDSTONE'

L. E. DeMumbrum

Lauderdale soils are developed from the Talahatta Formation of the Southern United States. The soils and parent material are of Eocene age and contain low-density solids which average 2.0 g per cc. The minerals present are mainly tridymite, cristobalite and quartz. Montmorillonite, mica and opaline silica are present. A 9A° diffraction maximum present in the samples containing no montmorillonite may indicate the presence of talc.

The very porous soil and parent material has a pH around 4.0. Under the existing conditions of high temperature and rainfall, the presence of montmorillonite and absence of kaolinite is of some interest. Presence of slightly soluble siliceous compounds such as opal in the soils may explain the presence of montmorillonite and the absence of kaolinite in the system.

Although the stronger lines of cristobalite and tridymite are present in most of the diffraction patterns, these are lost through treatment with hot, dilute NaOH or more slowly with hot 2% Na₂CO₃. The siliceous material is stable to 600° C. heat treatment, and is not appreciably soluble in 6 N HCl.

Presence of such minerals as alpha tridymite and alpha cristobalite (Table 1), thought to be formed at 870° C. and 1470° C., respectively, suggests a parent material of high temperature origin, perhaps a tuff.

So far as the writer knows, tridymite has not previously been reported in soils.

Table 1. X-ray Diffraction Maxima of Fine Silt from Lauderdale Soil

<table>
<thead>
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<th>D spacings, Å</th>
<th>9.82</th>
<th>5.15</th>
<th>3.34</th>
<th>2.57</th>
<th>2.04*+</th>
<th>1.56*</th>
<th>1.37*</th>
</tr>
</thead>
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<td>9.02</td>
<td>4.33*</td>
<td>3.07</td>
<td></td>
<td>2.49**</td>
<td>1.96**</td>
<td>1.53**</td>
<td>1.29**</td>
</tr>
<tr>
<td>6.23</td>
<td>4.05++</td>
<td>2.99*</td>
<td>2.39++</td>
<td>1.79++</td>
<td>1.50+</td>
<td>1.24</td>
<td></td>
</tr>
<tr>
<td>6.02</td>
<td>3.88*</td>
<td>2.82+</td>
<td>2.12+</td>
<td>1.61++</td>
<td>1.44+</td>
<td>1.20</td>
<td></td>
</tr>
</tbody>
</table>

*Spacing corresponds to alpha tridymite, A.S.T.M. index.
+Spacing corresponds to alpha cristobalite, A.S.T.M. index.
THE STUDY OF CLAY ON SOME GENETICAL SOIL TYPES IN YUGOSLAVIA

A. Skorić

In order to get information on the most active fraction dominating the soil dynamics and influencing the greater number of the physical, chemical and biological properties of soil, the author has investigated in the last few years the properties and quality of clay of the principal types of the Yugoslav soils.

Here are summed up most briefly the results of these investigations as regards podzols, brown podzolic soils, gray brown podzolic, terra rossa, degraded chernozems, brown forest soils, rendzinas, pseudogleys and gleys.

The molecular ratios $\frac{SiO_2}{Al_2O_3}$ amount for the most part to 2.0-3.0 dropping in brown podzolic soils somewhat below 2.0 and being 3.0 or more in rendzinas. This ratio is high in $A_2$-horizon of podzol and low in its $B_2$-horizon. The molecular ratios are lower than those mentioned as characteristic of montmorillonites but higher than those characteristic of kaolinites. The variations of these values within one type can be greater than the differences between the individual types of soils.

On the basis of the content of $K_2O$ it is possible to draw the conclusion that all the investigated soils contain also illitic minerals. Furthermore, almost all values amount to 2.0-2.9% $K_2O$, the content of $K_2O$ dropping somewhat below 2.0% only in the $A_2$-horizon of the podzols or in some eluvial horizons of the podzolized brown soil, and amounting in degraded chernozems to 4-5%.

Cation exchange capacity amounts in three-fourths of cases 30-40 m.e. on 100 g of soil, which corresponds to the values of illitic minerals. A fourth of data for C.E.C. amounts to 40-50 m.e. It is characteristic that within almost every soil type from different climatic zones these values are ranging 30-40-50 m.e. X-ray analyses have shown:

1. All the investigated soil types contain illitic minerals in the clay fraction;
2. Montmorillonite was not established in any sample;
3. Halloysite and $\alpha$-quartz were established in all soil types except in rendzinas.

The differential-thermal curves display mainly the same configuration. None of them is typical of montmorillonite or of kaolinite. Some of the curves in their terminal part are characteristic of illites, and some are unexpressed.

Electron-micrographs do not show kaolinite because there does not appear the characteristic hexagonal forms. Rodlets can be observed, and in most photographs are to be found in irregular forms.

The results show that there are no essential or sharp differences in the kind of clay minerals. The expected regularities in the distribution of individual groups of clay minerals in genetically different types were not confirmed. The data obtained show that for the kinds of clay in the minerals of the investigated soils the recent pedogenetic processes are not decisive. Our soils have developed on limestone dolomite, carboniferous sandstones and slates, diluvial loams, loess and alluvial deposits. All these are substrata preceded by ancient weathering. It is well-known that the secondary minerals from sedimentary parent substrata occur in the soil and render the genetical relationships of the soil types and groups of clay minerals difficult to be solved. Hence, the conclusion to be drawn is that illite and halloysite owe much of their presence to the fact that they were constituents also of the parent material of the present soils.
The paper deals with the results of studying the formation of red-brown and yellow-brown varieties of krasnozem. It has been revealed by chemical and mineralogical analyses that the red-brown variety is the product of basalt weathering which contains about 60% of plagioclase and the yellow-brown variety is the product of andesite weathering containing about 80% of plagioclase.

So far as the feldspars (plagioclases) are the essential mineral components of the primary rock, the process of their weathering represents the transformation of feldspars into clay minerals. The driving force of this transformation is the process of penetrating of protons into the crystal lattice of the feldspar the mechanism of which may be regarded as follows:

The solid phase (the feldspar) is turned towards the water with its Al-O and Si-O tetrahedra, alkaline and alkaline-earth cations being placed in the cavities between them. The cavities stacking with one another form canals in which only one single layer of cations may exist. Such a position of the cations allows a direct exchange with cations in the solution only on the external surface of the mineral, the exchange in the deeper layers being impossible. The cations cannot pass through the canals in the opposite directions, having the diameters less than the sum of the diameters of two exchanging ions. This cannot, however, impede the adsorption of protons. Being in water in the form of oxonium (OH₄⁺), they, contacting the alumino-oxygen tetrahedra of the minerals, migrate from water molecules to tetrahedra oxygens transforming them to hydroxyles, the lattice oxygens having a strong affinity to protons. Such adsorption neutralizes the electrical charge of the alumino-oxygen tetrahedra - the reason of cation adsorption. Having lost the source of its attraction, the cation moves towards the solution where it is electrically compensated by the anion which has accompanied the hydroxonium.

This process beginning from the surface gradually penetrates inside bringing about a topochemical rearrangement of the tetrahedral coordination into an octahedral one. The mineral acquiring a layer structure which is more stable when aluminium is surrounded by hydroxyles. Electron micrographs of the mother rock of the soil give evidence to the presence of montmorillonoids and kaolinites; the DTA curves show an increase in the OH-water content in the process of cation exchange with the protons. Both varieties show small exchange capacity (1-2m/e) and a high "exchange" acidity (34-29m/e) due to aluminium appearing in salt solution after the breakdown of acid alumino-silicate minerals of the montmorillonite type.

A rapid growth of plants on krasnozems favours the above process of mineral transformation. Plant roots extracting cations from the minerals give in exchange the protons, formed by plants in the process of oxidation of the synthesized organic matter.

It has been found that both varieties are practically identical from the chemical and mineralogical standpoints. The difference in color is due to more alkaline weathering conditions of the basalts, leading to the formation of the red-brown variety, than in the andesites, leading to the formation of the yellow-brown variety.
WATER-FERTILITY-CROP GROWTH RELATIONSHIPS

1. CYCLIC VARIATIONS OF CROP YIELDS INDUCED BY WEATHER THROUGH THE INTERMEDIARY OF THE SOIL. F. van der Paauw

2. THE RELATIONSHIP OF SOIL MOISTURE STRESS AND NUTRIENT AVAILABILITY TO THE GROWTH CHARACTERISTICS AND QUALITY OF WHEAT. W. L. Hutcheon and D. A. Rennie

3. INTERRELATIONS OF FERTILIZATION AND IRRIGATION OF FORAGES. Basil D. Doss, O. L. Bennett, and L. E. Ensminger

4. TIMING NITROGEN APPLICATIONS FOR MAIZE IN TROPICAL REGIONS CHARACTERIZED BY WET AND DRY SEASONS. Romeo C. Bruce and Edward H. Tyner

5. SWEET CORN PRODUCTION AS AFFECTED BY MOISTURE AND NITROGEN VARIABLES. C. O. Stanberry, H. A. Schreiber, C. L. Jenson, and M. Lowrey

6. INTERRELATIONS OF NITROGEN FERTILIZATION AND IRRIGATION OF COTTON. O. L. Bennett, C. E. Scarsbrook, B. D. Doss and R. W. Pearson

7. WATER USE EFFICIENCY AS RELATED TO NUTRIENT SUPPLY. H. R. Haise, F. G. Viets, Jr., and J. S. Robins
Correlations between meteorological conditions and crop yields have been stated frequently. In many cases the soil performs an important intermediary function.

The relation stated between the amount of winter rainfall and the crop responses to nitrogen fertilization depends on the leaching effect of rain. This was confirmed by an experiment in which part of the winter rainfall (62 mm = 28%) has been intercepted by a glass cover during heavy showers. The effect of this treatment equalled that of a dressing of about 30 kg of nitrogen pro ha. Rainfall during the growing season also appears to affect the nitrogen response of potatoes probably due to mobilization of soil nitrogen. The response of potatoes and wheat on clay soil to potash is higher in dry seasons. This might be attributed to changes of the amount of available potash in the soil.

Remarkable variations of crop yields in the course of years being of a cyclic nature often with a period of about 4-5 years have been observed in many cases on long term experimental fields, in average regional yields and also very regularly in the average yields of the Netherlands. These variations are relatively independent of the kind of soil and of the crop grown. Similar cyclic variations of some soil factors being still more pronounced than those of the yields occur frequently. Fluctuations of pH and content of water soluble phosphorus and those of the yield are correlated. The significance of these phenomena could be proved statistically.

It appears that these variations are induced or regulated by meteorological variations. Rainfall in the Netherlands in the last century has often been characterized by alternating rather constant periods of higher and lower rainfall generally lasting about 2 years or more. This clearly appears when a summation curve of rainfall is designed. The undulations of this summation curve are clearly reflected in the variations of soil factors and in the course of yields, so that a causal relation may be accepted. Thus the rhythmical movements of crop yields are also induced by summation effects of the weather upon the soil. The level of soil factors and yields is not only affected by the meteorological conditions of the current year but also to a large degree by those of preceding years.

Cyclic variations of crop response to lime and phosphorus deficiency have also been stated. These responses are correlated to variations of soil pH and content of water soluble soil phosphorus. Obviously they are also founded on cumulative effects.

Likewise a striking instance of a cyclic variation of nitrogen available to the crop has been noted on a soil being only little affected by the leaching effect of winter rainfall. Generally cyclic variations appear to be more pronounced on fertile soils. On less fertile soils well dressed with fertilizers the yields tend to be almost equal in most years.

The rather regular succession of increasing and decreasing yields indicates that the yield is largely determined by the intermediary of the soil as influenced by the cumulative effects of alternating long lasting periods of different weather (rainfall). The impression is obtained that these effects dominate those of other factors influencing crop yields.
THE RELATIONSHIP OF SOIL MOISTURE STRESS AND NUTRIENT AVAILABILITY TO THE GROWTH CHARACTERISTICS AND QUALITY OF WHEAT

W. L. Hutcheon and D. A. Rennie

Hard red spring wheat (Thatcher) was grown in the growth chamber under a wide variety of conditions of soil moisture stress, and with varying levels of supply of nitrogen and phosphorus. All crop replicates were grown in ten pounds of a black loam soil and water requirements for any particular moisture stress pattern were determined by weighing.

Under these conditions, and regardless of the characteristic quantity of available nutrients, the total crop yield and quality of the grain were a direct function of the water supplies within the range of available moisture for plant growth. The variation in quality was much more pronounced when nitrogen supplies were low, but significant variations still occurred when yields were not limited by a lack of either nitrogen or phosphorus.

A single period of moisture stress at any stage of crop growth, even though followed by favorable soil water conditions for the remainder of the growing period, also produced a very marked effect on yield, quality and composition of the crop.

The use of tracer phosphorus also showed that the relative proportions of soil and fertilizer phosphorus obtained by the crop varied considerably, depending on the moisture stress pattern and the supply of available nitrogen. It may be concluded that even a moderate water stress (never above one atmosphere) may have a detrimental effect on the plant root system. The alternative explanation must be that of an effect on the availability of nutrients.

The interpretation of growth experiments in the greenhouse or growth chamber, where small volumes of soil are used, are very markedly influenced by the soil moisture conditions maintained during the growing period. Both the upper and lower limits of water should be carefully regulated, and in a comparative manner, for each different type of soil.
Intensive management practices for forage production of the three most important warm season grasses of the Southern United States were studied at Thorsby, Alabama, during 1956-1959. The grasses, Coastal Bermudagrass (*Dygodon dactylon*), Bahiagrass (*Paspalum notatum*), and Dallisgrass (*Paspalum dilatatum*), were grown at six nitrogen levels ranging from 0 to 900 pounds per acre, with and without irrigation. Other nutrients and controllable growth conditions were made as near optimum as possible.

The yields of all three grasses were increased by both nitrogen fertilization and by irrigation alone, but a far greater response was obtained when both were used. Coastal Bermudagrass showed a considerably higher yield potential without irrigation but a less striking response to irrigation than did Bahiagrass. Dallisgrass was the least responsive of the three grasses to both irrigation and fertilization. Yields made by Bahiagrass in 1956 with irrigation and a relatively high rate of nitrogen applied separately and together are shown graphically in the figure below. The yield of dry forage produced by irrigation and nitrogen was nearly five times that of either one used separately.

When the grasses were well fertilized and irrigated, the efficiency of both nitrogen and water use was increased. This was illustrated in 1956 when irrigated coastal Bermudagrass with no nitrogen produced only 59 pounds of dry forage per inch of water used as compared to 532 pounds produced at the 600 pounds per acre nitrogen rate. The amount of dry forage produced per pound of nitrogen used during the same season at the 600 pound nitrogen rate was 16 pounds for non-irrigated and 30 pounds for irrigated coastal Bermudagrass.

INTERACTION OF NITROGEN AND MOISTURE LEVEL ON YIELD OF BAHIA GRASS. 1956.
TIMING NITROGEN APPLICATIONS FOR MAIZE IN TROPICAL REGIONS CHARACTERIZED BY WET AND DRY SEASONS

Romeo C. Bruce and Edward H. Tyner

The western part of the Philippine Islands of Luzon, Mindoro, Panay, Negros, and Palawan is characterized by pronounced dry and wet seasons. In spite of these strikingly different moisture regimes, the timing of the N application is similar; namely, half the total application at planting time. The remaining half is top-dressed 4 to 5 weeks later. The objective of this study was to determine the nitrogen application schedule which gave maximum N response for these seasons.

Results and discussion. The results are summarized in Table 1. A highly significant dry season response for 45 kilos of N applied in the row at planting time (Treatment 2) was secured. While yields were increased by an additional 45 kilos of N similarly applied (Treatment 6), these increases were not significant by the conservative levels of statistical significance employed. The yields of corn for treatments receiving similar total levels of N as Treatments 2 and 6 but applied largely as top-dressings were not significantly higher than the control (Treatment 1). The yields secured for the dry-season crop indicate that the greatest efficiency in N utilization and minimum risk in securing consistent N response can be expected when all N is applied in the row at planting time.

The results for the wet-season studies were confounded by the carry-over effects of the previous non-utilized dry-season N applications. Unfortunately this factor was not foreseen. All yields at the 45-kilo N level were increased. Only Treatment 5, however, was significant over the control (Treatment 1). At the 90-kilo N level, significant yield increases occurred for all treatments. No significance was observed between yields for Treatment 6 and those for Treatment 7, 8, and 9 which involved top-dressing. It is of interest to note that the yields of the latter did exceed that of Treatment 6. This suggests that with a properly designed experiment top-dressing may result in better N utilization for the wet-season crop.

Table 1. Summary of Maize Yields in 1958-59 Dry and 1959 Wet Seasons

| Nitrogen Fertilizer | At pltg. 4 weeks 7 weeks Dry season Wet season | N application (kg./ha.) | (In row) after pltg. after pltg. cav./ha. cav./ha. cav./ha. |
|---------------------|---------------------------------------------|-------------------------|-------------------------------------------------|----------------------------------------------------------------|
| Treatment No.       | 1                                           | 2                       | 3                                               | 4                                               | 5                                               | 6                                               | 7                                               | 8                                               | 9                                               | H.S.D. |
| Nitrogen Fertilizer | 0                                           | 45                      | 45                                              | 45                                              | 45                                              | 90                                              | 90                                              | 90                                              | 90                                              | 5%     |
| kg./ha.             | 0                                           | 45                      | 11.25                                           | 11.25                                           | 11.25                                           | 45                                              | 45                                              | 45                                              | 45                                              | 1%     |
| At pltg. time       | -                                           | 11.25                   | 33.75                                           | 22.5                                            | 22.5                                            | 22.5                                            | 67.5                                            | 22.5                                            | 45                                              | -      |
| Top-dressed         | -                                           | -                      | -                                               | -                                               | -                                               | -                                               | -                                               | -                                               | -                                               | -      |
| After pltg.         | 21.5                                         | 39.6                    | 45.9                                            | 26.6                                            | 25.9                                            | 31.5                                            | 32.2                                            | 30.4                                            | 34.9                                            | -      |
| Dry season cav./ha. | 55.3                                         | 73.5                    | 80.1                                            | 68.8                                            | 81.0                                            | 77.9                                            | 86.5                                            | 81.6                                            | 91.8                                            | -      |
| Wet season cav./ha. | -                                           | -                      | -                                               | -                                               | -                                               | -                                               | -                                               | -                                               | -                                               | -      |

Yields in cav./ha. numerically are approximately equivalent to maize yields expressed as bushels per acre.
SWEET CORN PRODUCTION AS AFFECTED BY MOISTURE AND NITROGEN VARIABLES

C. O. Stanberry, H. A. Schreiber, C. L. Jenson, and M. Lowrey

Golden Cross Bantam sweetcorn, T51 strain, was grown on Superstition fine sand at Yuma, Arizona, in a three-year investigation, 1957-1959, to evaluate the effects of moisture and supplemental nitrogen rates at various physiological stages of plant growth. Physiological stages used were planting to obvious joint at ground level (approximately 7 weeks); period of internode elongation - jointing to late boot (approximately 3-4 weeks); and fruiting, or period of pollination and grain development (tasseling and silking, followed by browning of silks and harvest - approximately 3 weeks).

The first year was devoted primarily to studying sweet corn response to different levels of moisture and supplemental N applications. The continuously wet irrigation level with 1/5 atmosphere maximum soil moisture tension before irrigation was superior to the "dry" treatment in which irrigation occurred when soil moisture tension reached 8 to 12 atmospheres. Supplemental N increased yields as much as 900%.

Special attention was given to association of moisture level with physiological stage of development during the second year. Although the continuously wet moisture level for the entire growing period was superior to the "dry" treatment, it was found that the beneficial effect was limited to the fruiting period only.

During the third year the timing of N application was associated with physiological stage of growth. The fruiting period appeared less critical for supplemental N than for abundant irrigation. It was important, however, to have adequate N available both during the period of internode elongation and during the fruiting period. This was accomplished by applying the smaller rate of N application at the beginning of each of these periods, or by applying the larger N rate initially, which allowed an abundant residual supply for later use during the periods when N was needed in larger amounts.
INTERRELATIONS OF NITROGEN FERTILIZATION AND IRRIGATION OF COTTON

O. L. Bennett, C. E. Scarsbrook, B. D. Doss and R. W. Pearson

Studies were conducted at Thorsby, Alabama, over a three-year period to determine the effects of irrigation and nitrogen level on yields and fiber quality of cotton. Cotton was grown with all combinations of four rates of nitrogen and three moisture levels. The nitrogen treatments were 0, 60, 120 and 240 pounds of N per acre in 1956-57 and 0, 120, 240 and 360 pounds of N per acre in 1958. Moisture levels were (M₁) not irrigated, (M₂) irrigated when approximately 65% of the available soil moisture was lost in the surface two feet of soil, and (M₃) irrigated when approximately 30% of the available soil moisture was lost in the surface two feet of soil. Water was applied by the furrow method. The soil was limed to a pH of 6.0 to 6.5 at the beginning of the experiment and was fumigated and subsoiled before each crop. All treatments were fertilized uniformly with 210 pounds per acre each of P₂O₅ and K₂O. The nitrogen was applied in split applications with 20 pounds being applied at planting and the remainder applied in two equal applications 30 and 60 days after planting. Near 100% insect control was maintained throughout the experiment.

Without irrigation there was a response only to the 60 pound rate of N. However, at the intermediate (M₂) moisture level there was a response to 120 pounds of N. At the highest (M₃) moisture level there was a yield response to 240 pounds of nitrogen. (See Figure.) When a combination of irrigation and high fertilization was used a yield of approximately 5,000 pounds per acre of seed cotton was produced. This was more than twice the yield obtained from either practice when used alone.

Lodging was severe at high rates of nitrogen and irrigation. Under these conditions, the amount of boll rot increased as nitrogen and moisture levels were increased; however, boll rot did not constitute a serious problem even where plants were lodged severely.

High nitrogen and moisture level caused a delay in maturity date, an increase in plant height, an increase in boll size, and a lower lint percentage. The greatest plant height obtained for any treatment was about 66 inches.

Cotton fiber data indicate that irrigation increased fiber length, elongation, and fineness but reduced fiber strength.

The effect of nitrogen and moisture levels on yield of cotton. Thorsby, Alabama, 1956-57. M₁ and M₂ treatments were irrigated to field capacity when approximately 65 and 30 percent of the available soil moisture was lost in the surface 2 feet of soil, respectively.
WATER USE EFFICIENCY AS RELATED TO NUTRIENT SUPPLY

H. R. Haise, F. G. Viets, Jr., and J. S. Robins

The concept of increasing efficiency of water use by raising soil productivity with fertilizers is not new. Briggs and Shantz recognized the importance of this relationship in 1913 and used the term "water requirement" (ratio of pounds of water to pounds of dry matter produced) to differentiate efficiency of water use by various crops. They concluded, after extensive review of literature, that with few exceptions the water requirement was reduced where fertilizers were used.

More recently, the authors have pointed out the desirability of expressing water requirement as the reciprocal; namely, water use efficiency (WUE) or the units of marketable crop produced per unit depth of water used in evapotranspiration. Such an expression appears more meaningful in describing to the farmer, for example, advantages of certain practices such as fertilizer use in making more efficient use of available water supplies.

Water use efficiency depends upon evapotranspiration and dry matter production or other products of CO₂ assimilation. Penman and Schofield maintain that maximum evapotranspiration depends almost entirely on meteorological conditions and scarcely at all on the nature of the vegetation as long as it is green (in a stage of vegetative growth), effectively covers the soil and is adequately supplied with water. Considerable evidence is available to indicate that dry matter production does vary within broad limits with about the same amount of water use under certain climatic conditions.

Data presented in Table 1 are typical of increased dry matter production of grass obtained from various nitrogen applications at Bushland, Texas, where evapotranspiration was essentially the same for all treatments. These data clearly show that W.U.E. can be increased where a yield response to added fertilizer is obtained. However, increasing W.U.E. does not necessarily mean that less water is used in evapotranspiration. It is also true that the highest W.U.E. may not be an economical level of production as is sometimes the case where moisture limits crop production.

Table 1. Evapotranspiration and water use efficiency (WUE) of irrigated Blue Grama with variable rates of nitrogen

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<td>0 lb. N/ac.</td>
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<td>30.82 inches</td>
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</tbody>
</table>

¹Unpublished data J. J. Bond, George Ellis, and T. J. Army, Texas Agricultural Experiment Station and U.S.D.A. Southwest Great Plains Field Station, Bushland, Texas.

²Pounds D. M. per inch E. T.

³Three irrigations plus 7.8 inches of rainfall.
MISCELLANEOUS CONTRIBUTIONS IN SOIL CHEMISTRY

1. COBALT-IRON RELATIONSHIP IN SANDY SOILS. Joe Kubota and Victor A. Lazar
2. SOME EFFECTS OF ALUMINUM ON TESTING FOR LIME REQUIREMENT OF SOILS. E. O. McLean, H. E. Shoemaker, and W. R. Hourigan
3. SOIL ACIDITY AND ALUMINUM STATUS AS AFFECTED BY SOME NEUTRAL SALTS. T. L. Yuen
4. ALUMINUM TOXICITY OF CERTAIN SOILS ON THE COAST OF BRITISH GUIANA AND PROBLEMS OF THEIR AGRICULTURAL UTILIZATION. N. Ahmad
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11. REDUCTION ET COMPLEXATION DU FER DES SOLS PAR LES EXTRAITS DE LITIÈRES FORESTIÈRES. P. Lossaint
12. EXTRACTION FRACTIONNÉE DES COMPOSÉS DE FER ET D'ALUMINIUM DANS LES SOILS TROPICAUX. J. A. E. Rondelet
Sandy and loamy sand soil areas of eastern United States are commonly associated with reports of cobalt deficiency in animals grazed on forages grown thereon. The various sandy soils have strikingly different morphologies associated with differences in humus and iron. Changes in cobalt associated with iron were investigated, using nearly 300 samples from 42 soil profiles of seven great soil groups, including Regosols, Humic and Low-Humic Gley soils, Ground-Water Podzols with humus B horizons and with humus-iron B horizons, Podzols, Brown Podzolic soils and Alluvial soils.

The distribution of cobalt paralleled that of iron in all soil profiles. The cobalt content was consistently lowest in the Ground-Water Podzols with humus B horizons of southeastern United States. Sandy soils of northeastern United States formed in glacial drift deposits had larger amounts of both cobalt and iron than did the southeastern soils.

Cobalt and iron also showed a linear relationship in each major horizon - A, B and C - of Podzols, Brown Podzolic soils and Ground-Water Podzols. However, cobalt was measurably lower per unit of iron in the A than in the C horizon (Figures 1 and 2). Where data are related to groups of similar soil profiles, it appears that iron increases exponentially with cobalt in soils with B horizons but as a linear function in soils lacking profile development (Regosols). The logarithmic relationship for soil profiles in contrast to a linear relationship for soil horizons, relates to differences both in slopes of the relationship lines and amounts of cobalt and iron present in the A and B horizons.
SOME EFFECTS OF ALUMINUM ON TESTING FOR LIME REQUIREMENT OF SOILS

E. O. McLean, H. E. Shoemaker, and W. R. Hourigan

Highly weathered acid soils often contain appreciable amounts of extractable or exchangeable aluminum and require large amounts of lime for neutralization. Such soils do not lend themselves to the accurate determination of the lime requirement by certain existing rapid soil test methods. Fifteen Ohio soils with small to large amounts of extractable Al were selected for study. Samples of each soil were treated with increasing rates of calcium carbonate and moist incubated for 17 months. The Woodruff (p-nitrophenol-Ca acetate) method for determining lime requirement was found to be unsatisfactory on these soils without major alteration.

The Mehlich buffer (triethanolamine) method was also found wanting for determining total acidity of individual soils with increments of lime added. The total acidity measured by the Mehlich method includes a component of acidity not normally neutralized by liming practice. This is the acidity which exists between the near neutral pH to which the soil is limed and the pH of 8.1 to which the soil is neutralized by the triethanolamine buffer. When applied to the entire group of soils the Mehlich method gave a good indication of the average amount of lime required to bring the soils to pH 6.8. This meant there was an unmeasured component of acidity which was compensating for the component above pH 6.8. When the equivalents of acidity between pH 5.8 and pH 8.1 were deducted from, and the equivalents of Al extracted with NH₄OAc @ pH 4.8 were added to the acidity measured with the triethanolamine buffer; the result was highly indicative of the lime requirement of the group of soils and individual soils with increasing rates of lime applied. Individual soils varied as to whether extractable Al equaled, exceeded, or was exceeded by the acidity between pH 6.8 and pH 8.1.

Examination of the soil-buffer equilibrium reaction suggested that for soils with considerable extractable Al a much weaker buffer solution than the Woodruff buffer is needed for indicating lime requirement. A new buffer was developed from a mixture of triethanolamine, paranitrophenol, potassium dichromate, and calcium acetate in combination with CaCl₂. Appropriate concentrations of these components, soil to buffer ratio, and shaking time were selected. The amounts of depression in pH of the buffer by the above soils were highly indicative of the amounts of lime required to neutralize them under moist incubation.

Samples of another group of 12 soils were treated with HCl and with AlCl₃. Hydrogen and Al were about equally effective in increasing the acidity as measured by the Mehlich method. Relative enrichment with Al by the above treatments tended to increase the amount of base required to increase the pH of these soils from 6.8 to 8.1. The Al treatment of soils already nearly saturated with Al did not significantly change the depression in pH of the Woodruff buffer but did appreciably change the pH depression of the new buffer. In all soils and with both buffers the HCl treatment significantly increased the depression in pH of the buffers by the soils.

Results obtained with the new buffer were found to correlate well with the amounts of Ca(OH)₂ required to neutralize a group of 101 soils selected to represent the range from low to very high lime requirement. Thus on the basis of the results from three different groups of soils, the new method was justified as a rapid test for lime requirement of mineral soils whether low or high in extractable Al.
SOIL ACIDITY AND ALUMINUM STATUS AS AFFECTED BY SOME NEUTRAL SALTS

T. L. Yuan

Four soils, Leon fine sand, Norfolk, Faceville, and Red Bay fine sandy loams were equilibrated with a number of neutral salt solutions. The weight ratio of soil to solution was 1:2.5. No appreciable difference was found in either the pH of the soil suspension or that of the supernatant solution between chlorides and nitrates with the exception of magnesium nitrate which gave a lower pH than magnesium chloride. Sulfates resulted in considerably higher values of pH in both the soil suspension and the supernatant solution than chlorides and nitrates. The titratable acidity in the supernatant solution was highest for the sulfates while the chlorides were only slightly higher than nitrates. There was a close correlation between aluminum concentration and the titratable acidity.

Neutral barium salts produced the highest acidity in the supernatant solution followed in decreasing order by calcium, potassium, sodium and magnesium. However, the position of magnesium and sodium was reversed when nitrate was used as the anion.

As salt concentration of the solutions was decreased, the pH of the soil suspension and that of the supernatant solution increased while the titratable acidity and aluminum content decreased. In salt solutions of a half normal concentration or less, potassium sulfate produced lower titratable acidity and aluminum content than the corresponding concentration of chloride, the reverse was true for solution of normal concentration.

The titration curves of soils in presence of salts at half normal concentration were determined in a soil to solution ratio of 1:5. The amount of calcium hydroxide required to bring the suspensions to the neutral point varied with the salt used. It was also observed that with changing concentration of a single salt, there was a corresponding change in the amount of calcium hydroxide required.

These investigations demonstrate the changes in soil pH, exchange acidity and active aluminum concentration which may occur in presence of salts commonly used in soil fertilization. The results show that the common practice of determining pH in water suspension does not necessarily give a true picture of soil acidity and other related chemical properties. It is suggested that the measurement of soil pH and lime requirements using dilute solutions of fertilizer salts instead of distilled water would more accurately measure field conditions.
ALUMINIUM TOXICITY OF CERTAIN SOILS ON THE COAST OF BRITISH GUIANA
AND PROBLEMS OF THEIR AGRICULTURAL UTILIZATION

N. Ahmad

Very roughly, about one quarter of the coastal soils of British Guiana are characterized by high available aluminium (extractable by 0.5 N acetic acid) in the profile. These soils lie between the frontland clays and the white sands and are still largely undrained. High aluminium content in these soils is also often associated with high soluble sulphate and acidity.

Due to the ecological environment the profile is organic ranging from almost pure "pegasse" or peat to more decomposed and incorporated organic matter overlying clay. In some cases there is a buried layer of organic matter. High aluminium is always associated with high organic matter content in the soil except where the peat has been burnt either spontaneously or accidentally leaving a residue rich in aluminium with little organic matter. On the aluminium soils the vegetation consists of a few species of sedges, ferns, and marsh loving palms all of which are capable of tolerating high amounts of aluminium in their tissues and in the soil. These plants act as converters of aluminium in the soil from difficultly available forms to more readily available ones resulting with the passage of time of a build up of available aluminium in the surface layers.

As the exploitation of more suitable lands on the coast progresses, there is pressure to extend agriculture to some of these soils with largely unsuccessful results so far. Rice and sugar cane, the country's two most important crops have failed on these soils; experiments with jute have shown it to be very sensitive to high aluminium and therefore not suitable. The only crops which can tolerate this condition to a certain extent are coffee, pineapples, and certain tropical root crops such as cassava, eddoes, tannias and yams. It is felt that certain indigenous grasses might also be successfully grown on these soils.

The effect on the plant of high soil aluminium has been twofold. First, there is the direct deleterious effect on the roots, killing root hairs and young roots and causing abnormal root development. There has also been the effect of induced phosphate deficiency. Crops grown on these soils have shown a lower phosphate content in the tissues as compared to the same crops growing on better soils.

Most of these soils were found to have a high lime requirement. In experiments using 5, 6, 7, 8, 9 and 10 tons per acre equivalent of limestone, phosphate at 1,000, 5,000 and 10,000 parts per million, and three moisture regimes, i.e. friable, field capacity and 100% saturation, severe phosphate fixation was observed and after about three months considerable reduction of available aluminium has been noted especially in the soil kept at field capacity around 100% saturation. On standing for over six months, there has been a progressive improvement in the situation. Soil acidity behaved similarly.

When the phosphate dressings were added before lime its fixation was considerably less and a more rapid and marked reduction of available aluminium was noted.
INFLUENCE OF THE PARENT MATERIAL AND OF UTILIZATION OF THE LAND ON THE MOBILE ALUMINUM CONTENT IN THE SOIL

B. Dobrzanski

Our first investigations on mobile aluminum were started more than 10 years ago, and our first paper on this subject was published in 1953.

The results obtained in our laboratory show that mobile aluminum occurs in soils the reaction of which is below pH 5 in KCl, but in some soils mobile aluminum was found when soil acidity decreased to pH 5.8.

The greatest quantity of mobile aluminum was found in podzolic soil, acid brown soils, and in mountain immature soils. Smaller quantities of mobile aluminum were found in brown soils proper.

Small quantities of mobile aluminum occurred only in some profiles of alluvial soils, black earths and degraded Chernozems. Rendzina soils, as it could be expected, contained no mobile aluminum.

About 1000 soil samples taken from more than 300 profiles of various soils over the whole territory of Poland were tested for the content of mobile aluminum.

The tested samples represented podzolic and brown soils, Chernozems, black earths, alluvial soils, bog soils, and rendzina soils. These soils were formed from various parent materials and were covered by forests, meadows and pastures, or used as arable land.

Mobile aluminum was determined by the frequently used method of Sokolov.

On the strength of our latest investigations, we should like to present conclusions concerning the influence of the parent material and the utilization of the mobile aluminum content in the soil.

1. The tested samples came from soils formed from sands of pelagic origin, from glacial sands and loam, loess, water-derived formations, and from deposits of the Carpathian flish, sandstone and slate.

Soils formed from the sandstone of the Carpathian flish, and especially from the Magurian sandstone, contained the greatest quantity of mobile aluminum (117 mg/100 g of soil).

It should be noted that the dominant clay mineral in this soil is mica.

Smaller quantities of mobile aluminum were found in soils formed from glacial deposits and water-derived formations, and the smallest amount in soils derived from loess. In the loess soils the dominant clay mineral is illite.

2. The manner in which a soil is utilized has a decisive influence on its content of mobile aluminum.

Soils under forests, and especially under coniferous forests, contain much more mobile aluminum than identical soils covered by perennial meadow, pasture vegetation or cultivated soils.

Experiments with fertilizers conducted over a period of 40 years have shown that fertilization influences the content of mobile aluminum in the soil. An especially marked increase of the mobile aluminum content can be observed after dressing with ammonium sulphate.
THE FIXATION OF THE (NH₄)⁺ ION BY THE CLAY COMPLEX

Pedro Mela

The adsorption of the (NH₄)⁺ ion by the clay complex displays two features: 1. "Retention" of the ammonia in an exchangeable form by the negative superficial charge which mainly depends on the total exchange capacity of the mineral and 2. "Fixation" of the ammonia by the interior surfaces of the particle, which changes with the interlaminar separation and structure, with the intermolecular attraction and with the elasticity of the mineral which increases with temperature and moisture. Interlaminar separation must be greater than the diameter of the (NH₄)⁺ ion (2.86 Å) and the NH₄⁺ must remain enclosed in the hexagonal spaces which are formed by the tetrahedral oxygen rings in the interlaminar surfaces.

The superficial minerals immediately come into contact with available ammonia, fixing a variable quantity of it, and since the conditions for nitrification in the surface soil are much more favorable than in the subsoil, our results, which show that the subsoil fixes much more ammonia than the surface soil, are logical. Furthermore, we find the latter in its most superficial layer exposed to changes in moisture and temperature which augment the fixation.

We have proved that the fixation of NH₄⁺ by the soil is somewhat superior to fixation by the subsoil after a previous treatment of washing it twice a month throughout a whole year.

Employing simple minerals and adding 20 meq. of ammonia per 100 gr. montmorillonite fixed 25% by means of desiccation and 50% by moistening, while illite fixed 10%, owing to the fact that its K⁺ compounds allow only a small amount of expansion. Kaolinite fixes much less due to the strong interlaminar hydrogen bonding. Heating to 100°C increases the fixation especially if it has previously been treated with sodium carbonate.

Experience with natural soils shows that fixation increase with montmorillonite content and that the percentage of the fixed ammonia is in inverse ratio to the added ammonia, because if the added ammonia amounts to 2 meq. 55% is fixed while an addition of 45 meq. gives 8% fixed. When one adds 20 meq. and heats it to 100°C, 7 meq. will be fixed, that is to say double the amount when dried at 25°C and four times this amount when moistened during 36 hours.
Previous experiments have shown that the amount of exchangeable potassium is no good measure of potassium available to the plants in Norwegian soils, especially in clay soils. Better correlations were obtained between yield and amount of potassium soluble in 1 N nitric acid.

Eleven different Norwegian soils of different texture and origin were examined in pot experiments as to their potential to supply the plants with potassium. The experiments lasted for 5 years and soils without and with potassium fertilizer added were tested. Each year two crops were taken, barley as the first crop and oats as the second.

Total exchangeable potassium, potassium soluble in monochloracetate, potassium soluble in 1 N nitric acid, potassium soluble in 11 N sulfuric acid and potassium released to a cation exchange resin were determined previous to the experiments. Each year after the harvest readily and acid soluble potassium were determined to control changes in the content of potassium in the soils.

The content of total exchangeable potassium according to Kolterman and Truog was high in clay soils and in till soils derived from a black mudstone, in the other soils the content was low. The clay soils and soil rich in mica minerals all contained large amounts of potassium soluble in 1 N nitric acid.

Apart from two samples of sandy and silty clay and samples of poor sand and silt the plants took up more potassium from the soils than the amount of exchangeable potassium. The amount of potassium released to the cation exchange resin was about of the same order as the amounts taken up by the plants. There was a close correlation between the decrease in potassium soluble in 1 N nitric acid during the experimental period and the amount of potassium taken up by the crop from unfertilized soils. Variations, probably due to potassium fixation or release were observed.

No statistically significant correlations between amount of readily soluble potassium in the soils and potassium uptake by the plants or percentage yield were obtained. The correlation between potassium uptake and yield on one side and potassium soluble in 1 N nitric acid, in 11 N sulfuric acid and potassium released to cation exchange resin was highly significant, the correlation coefficients for the 5 year period ranging from 0.91 to 0.97.

The above results were corroborated by determination of readily soluble and acid soluble potassium in different soils and in samples from soil profiles of several soil groups.

Silt and very fine sand generally contained small amounts of soluble potassium beyond the exchangeable amount. This was also true for most of sandy soils, but some of them contained considerable amount of acid soluble potassium. In the clay soil there were generally large amounts of moderately available potassium. Little or no correlation was found between the content of readily soluble and acid soluble potassium.

Thus the potassium status of Norwegian soils and presumably also in other areas, cannot be determined by the amount of exchangeable potassium alone.
EFFECT OF CROP, FERTILIZER AND LEACHING ON CARBONATE PRECIPITATION AND SODIUM ACCUMULATION IN SOIL IRRIGATED WITH WATER CONTAINING BICARBONATE

P. F. Pratt, R. L. Branson and H. D. Chapman

Data presented show the amounts of lime precipitated in soils of a 20-year lysimeter experiment and of a 38-year field trial, both of which were located at Riverside, California, and irrigated with water from the same source. The water had an average composition of 3.0 me. HCO₃, 2.43 me. Ca, 0.76 me. Mg, and 1.46 me. Na per liter.

In the lysimeter experiment the calcium carbonate precipitated in the soil varied from 4,000 to 19,400 pounds per acre with an average of 10,550 pounds per acre. The average represented 86 percent of the total calcium accumulation (total added minus total removed). The other 14 percent was necessary to completely base saturate the soil. In soils treated with straw or the growth of mustard cover crops the regression equation for calcium carbonate in the soil as a function of percent leaching was \( Y = 29,750 - 2852X \), with a highly significant correlation coefficient of (-0.96). For the growth of vetch or melilotus legumes the regression equation was \( Y = 32,000 - 4320X \), with a significant correlation coefficient of (-0.82). There is a significant difference between the two regression coefficients and thus the different crops have effects that are not related to leaching percentages. The amount of calcium carbonate precipitated was significantly correlated with the amount of calcium added in the water, fertilizer and organic materials.

The precipitation of the bicarbonate in the irrigation water varied from 38.1 to 111.0 percent and was significantly correlated with an index obtained by measuring the difference between the pH of the soil and the pH of a solution in equilibrium with calcium carbonate at the bicarbonate and calcium concentration of the irrigation water. The data suggest that the calcium added to a base-saturated soil is either removed by the crop or by drainage water or is precipitated as calcium carbonate if bicarbonate is present in the irrigation water.

The sodium adsorption ratio (SAR) of the saturation extract and the exchangeable sodium percentage (ESP) of the soil were both increased by calcium carbonate precipitation and by preferential absorption of calcium and magnesium vs. sodium by crops, and both were decreased by application of calcium nitrate.

In the field trial about half the added calcium was precipitated as calcium carbonate. In two treatments where no fertilizers were added the sodium percentage in the saturation extract of the soil predicted from calcium carbonate precipitation data was 46 percent and the determined sodium percentages were 48 and 43. The prediction was based on the reaction, \( \text{Ca} + 2\text{HCO}_3^- = \text{CaCO}_3 + \text{H}_2\text{O} + \text{CO}_2 \) with a corresponding increase in sodium percentage in the water in the soil.
SOIL SEQUENCES AS AN AID TO SOIL AND PLANT CHEMISTRY

N. Wells and N. H. Taylor

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<th>New Zealand Soil Name</th>
<th>Rainfall in mm</th>
<th>Natural Vegetation</th>
<th>Secondary Minerals</th>
<th>Topsoil pH</th>
<th>Average composition of topsoils</th>
<th>Average composition of sweet vernal grass</th>
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<td></td>
<td></td>
<td></td>
<td>%</td>
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<td>Soil sequence from dacite and rhyolite (pumice, rock)</td>
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<td>Soil sequence from siliceous sedimentary and metamorphic rocks (loess, sediment, rock)</td>
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<td>10</td>
<td>16 Sb</td>
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<td>silica</td>
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1 - Recent soil  
2 - Brown loam (mod. leached)  
3 - Brown loam (str. leached)  
4 - Brown loam (ironstone)  
5 - Yellow-brown loam  
6 - Brown granular clay  
7 - Yellow-brown pumice  
8 - Yellow-brown earth  
9 - Podzol  
10 - Brown-grey earth  
11 - Yellow-grey earth
EXPERIMENT OF AN AGROCHEMICAL SOIL CHARACTERISTIC

G. S. Davtyan

One of the main problems in agrochemistry is the agrochemical characteristic of the soil cover of this country. Its aim is the elaboration of chemical products application in agriculture, planning, consumption, production, distribution and use of fertilizers, soil maps, even on a detailed scale do not solve this problem.

These present-day questions are solved by means of a field experiment network and agrochemical soil analyses. The larger the quantity of experiments the greater is the accuracy and the authenticity of the results achieved.

These experiments must be supplemented by a many-sided and close examination of a limited quantity of basic points, selected with the help of soil maps. These basic points must include the most representative soil types and their natural and agricultural varieties. The agrochemical laboratory of the Academy of Science of the Armenia SSR at present is completing the first stage on an agrochemical characteristic of Armenia soils.

The soil cover of Armenia SSR is so complex that the usual method of agrochemical investigations would require great efforts, and the obtained variegated data would not help to find out the main relationships. A many-sided agrochemical investigation of reasonable selected basic points helps to elaborate a detailed agrochemical characteristic of the main soil types and varieties. On the basis of a detailed agrochemical characteristic the main questions of agriculture may be solved.

The results of these works are laid down in brief, and as examples some experimental data are presented.
REDUCTION ET COMPLEXATION DU FER DES SOLS PAR LES EXTRAITS DE LITIÈRES FORESTIÈRES

P. Lossaint

Nous avons montré lors du dernier Congrès International de la Science du Sol que les litières forestières étaient capables de mettre en solution des quantités appréciables de fer dans un sol et que l'effet de solubilisation était variable selon l'essence forestière utilisée et le degré de décomposition de cette dernière.

La quantité de fer dissoute est fonction de plusieurs facteurs: la quantité de matière organique soluble libérée par les litières, leur acidité hydrolytique et leur richesse en polyphénols, les deux premiers facteurs étant eux-mêmes fonction du degré d'aération du milieu de décomposition.

Quant aux mécanismes de la mise en solution et du transport du fer, ils sont de deux types: 1) réduction du fer sous l'influence des extraits; 2) formation de complexes avec Fe²⁺ et Fe³⁺.

1) Tous les extraits de litière sont capables de réduire une certaine quantité de fer à l'état ferreux. Les mesures quantitatives effectuées à pH 2,5 sur huit litières ont donné les chiffres extrêmes suivants:

- quantité de fer réduite par l'extrait de 100 g de litière, 2,77 à 0,046 g;
- fer réduit par gramme de substance hydrosoluble, 0,142 à 0,123 g.

Dans l'ensemble les feuillus présentent des valeurs plus élevées que les résineux. Ceci est en rapport avec leur teneur plus forte en polyphénols. Au cours de la décomposition ce pouvoir réducteur diminue fortement dans ce premier groupe d'espèces et reste constant chez les résineux.

Lorsqu'on fait décomposer les litières en conditions anaérobies le pouvoir réducteur des extraits est sensiblement doublé.

2) Le pouvoir complexant a été mesuré de la façon suivante: on détermine la quantité de matière organique (extrait) nécessaire pour maintenir le fer en solution en milieu basique. Les valeurs trouvées pour différentes litières se situent entre 5,16 et 0,73 g de fer complexé par l'extrait de 100 g de litière et 0,31 à 0,16 g par g de matière hydrosoluble. La quantité de Fe₂O₃ complexé est essentiellement fonction de la quantité de matière organique libérée par les litières, et à un degré moindre de la nature chimique de ces extraits. Le fer ferreux nécessite moins de substance organique pour être complexé. Il faut admettre devant ce résultat qu'en présence de Fe³⁺, la matière organique le réduit partiellement et par voie de conséquence s'oxyde. Cette matière organique oxydée aurait donc un pouvoir complexant moindre que la matière organique non oxydée.

Lorsqu'on fait décomposer les litières en milieu anaérobie, le pouvoir complexant est sensiblement doublé: Ce résultat confirme l'hypothèse émise ci-dessus.

En présence de quantités croissantes de Ca²⁺, le pouvoir complexant diminue très fortement pour devenir nul pour une concentration de la solution en ions Ca²⁺ de 100 p.p.m.

Quant à la nature chimique des complexes formés, l'ensemble des expériences entreprises sur cette question fait penser qu'il s'agit d'un effet de peptisation et de protection de l'hydroxyde de fer colloïdal par les extraits. Il s'agit par conséquent de complexes colloïdaux.
Expression des résultats expérimentaux.

a. Oxydes de fer et d'aluminium.

L'aluminium et le fer, entrant en solution, s'y trouvent en présence d'un grand excès de réactif. Ils n'utilisent, de ce fait, qu'une petite fraction de l'acide oxalique. La probabilité de la réaction est proportionnelle au nombre d'aluminium et de fer susceptibles de réagir à un temps donné. Nous obtenons ainsi une réaction du premier ordre, le mécanisme de dissolution obéissant à la loi de décroissance donnée par la relation:

\[ \frac{dQ}{dt} = kQ \]

k est un facteur cinétique lié aux propriétés physiques et physico-chimiques des substances étudiées.

A partir des vitesses instantanées, relevées sur les courbes de dissolution, il est possible de connaître la constante k, qui n'est autre que la pente de la droite obtenue en portant en diagramme le ln (dQ/dt) en fonction du temps. La quantité de produit est connue par le rapport de la vitesse au temps \( \frac{t}{o} \) à la constante k.

En présence de corps ayant plusieurs constantes cinétiques (ce qui semble être le cas pour la gibbsite), il suffit d'opérer d'une façon identique à partir du dernier produit entrant en solution, et de déduire, pour chaque corps, les vitesses de solubilisation, des composés moins solubles, de la vitesse totale.

b. Kaolinite.

Deux équations cinétiques traduisent correctement la solubilisation d'une kaolinite bien cristallisée

\[ (1) - Q_s = Q_o \left( e^{-k_1 t} + Q_0 \left( e^{-k_2 t} \right) \right) \]

ou \( Q_s \) est la quantité solubilisée au temps \( t \)

\[ (2) - Q_s = a_o \left( e^{-k_1 t} \right) + \left( k_2 + k_2' \right) \left( e^{-k_2 t} \sqrt{2\pi} \right) \int_{0}^{t} \left( e^{-\left( k_1 t \right)} \right) \frac{1}{\sqrt{2\pi}} \right) \]

\( a_o \) est une quantité d'aluminium semblant limiter les phénomènes de diffusion

\( k_2' \) et \( k_2'' \) sont des constantes cinétiques attribuables à deux phénomènes la variation de \( k_2' \), au cours du temps, procède de la même exponentielle que celle de \( a_o \).

Des résultats expérimentaux, et l'application de ces équations, à d'autres kaolinites, pures ou en présence de gibbsite, seront présentés.
ÜBER DIE NATUR KOMPLEXER EISEN-ORGANISCHER VERBINDUNGEN IM BODEN

I. S. Kauritschew, E. W. Kulakow and E. M. Nosdrunowa

In der Arbeit werden die Eigenschaften eisen-organischer Verbindungen betrachtet, die sich bei der gegenseitigen Einwirkung zweiwertigen Eisens gleigier Böden mit den wasserlöslichen Formen organischer Stoffe des Bodens und der Pflanzenrückstände bilden. Die Autoren untersuchten die in Lösung übergehenden eisen-organischen Verbindungen mit der Methode der Elektrodialyse und Filtration der Lösungen durch Ionenaustauschharze.


Die Autoren führten einen Vergleich der Eigenschaften natürlicher Eisenlösungen, die aus dem gleigigen Boden durch destilliertes Wasser im Kohlensäurestrom (mit nachfolgender Oxydation des Eisens an der Luft) abgeteilt werden, und künstlicher Eisensole durch. Im Unterschied von den künstlichen Solen, haben die natürlichen Lösungen der Eisenverbindungen negative Ladung, gehen leicht bei schwacher Ansäuerung in Ionenform über, haben einen höheren Dispersiongrad, eine höhere Beständigkeit bei der Zufügung organischer Stoffe und werden von amorpher Kieselsäure nicht aufgehalten.


Auf Grund der Untersuchungen sind die Autoren der Meinung, daß die Bildung eisen-organischer Komplexe mit Eisen (II) durch die Anwesenheit niedrigmolekularer Säuren, Aminosäuren, Verbindungen vom Typ der Polyphenole saurer Polysaccharide, Gerbstoffe und Fulvosäuren im Bestand der wasserlöslichen organischen Stoffe möglich wird.

Die hier betrachteten Materialien lassen es zu von der Möglichkeit der Bildung eisen-organischer Verbindungen dort zu sprechen, wo sich zeitweilige anaerobe Verhältnisse bilden und biochemische Reduktionsprozesse auftreten. Diese Verhältnisse können durch das Redox-Potential charakterisiert werden.

Die Untersuchungen der Dynamik der Sesquioxyde, unter ihnen auch Eisen-(II), und des Redox-Potentials (rdp) lassen es zu zu sagen, daß die Bildung komplexer eisen-organischer Verbindungen bei der Formierung podsoliger Böden, Moorböden, und außerdem von Solod, Solonetzboden und podsoliger Böden der Steppenniederungen vor sich geht.
SOIL SURVEY AND ITS APPLICATION

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2. USE OF AERIAL PHOTOGRAPHS FOR DETAIL SOIL SURVEY. U. A. Liverovski and M. S. Simakova
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SOIL REGIONAL SUBDIVISION

D. G. Vilensky

Soil regional subdivision is a division of the territory into parts characterized by a more or less uniform soil cover. It is carried out by summarizing the materials of soil maps with reference to soil-forming rocks, topography, natural vegetation and agricultural soil use. Soil regional subdivision is a generalization of our knowledge of the distribution, constitution, composition and fertility of soils. It is of a great theoretical and practical importance for national economy.

In the USSR soil regional subdivision is necessary for planning and solving most of the agricultural problems, such as:

1. Application of regular systems of agriculture.
2. A regular specialization and distribution of agricultural branches, with reference to the natural and economical conditions.
3. A regular distribution of crops and their sorts.
4. Application of a differentiated agrotechnics in accordance with the profile, composition and properties of soil.
5. Planning the crop yields.
6. Planning and realization of soil reclamation measures.
7. Planning and realization of the measures of soil conservation and erosion control.
8. Planning the delivery and distribution of fuel in accordance with soil conditions for the work of agricultural machines.
9. Planning the delivery and distribution of the mineral fertilizers in accordance with the soil conditions of the regions and a regular application of local organic fertilizers.

At present in the USSR the following taxonomic unit system of natural soils has been adopted for soil regional subdivision: soil zone, soil subzone, soil province, soil district, soil region.

The principal unit of soil subdivision is the soil region which is understood as a part of the territory, characterized by a uniform soil cover in respect to soil subtypes and varieties combination, characterized by the uniformity of the chief soil-forming rocks and other factors and conditions of soil formation.

During regional subdivision of soils it is necessary to take into account the character of agricultural influence upon soil-forming conditions (reclaimed and nonreclaimed lands, drainage, irrigation, development of erosion processes, secondary salinization, cultured state of the soils.) In the dependence to the degree of this influence within a region subregions may be distinguished.

So far as the soil is the main means of production in agriculture, it is necessary besides natural to distinguish natural-economical belts according to their economical use, connected with the administrative and economical subdivision.

Recently under the supervision of the author a map has been compiled of soil regions of the European part of the USSR and the Caucasus on a 1:1500000 scale, on which 686 soil regions are distinguished. Another map of soil regions of the Asiatic part of the USSR on a 1:2500000 scale is being prepared. Besides, a map of natural-economical soil belts of the USSR on which 48 soil belts are distinguished has been compiled.
USE OF AERIAL PHOTOGRAPHS FOR DETAIL SOIL SURVEY

U. A. Liverovski and M. S. Simakova

Aerial photographs are all the wider applied in various countries when investigating the soil cover and compilation of soil maps. But big possibilities as regards to these materials are far from being exhausted. One of the causes determining insufficient use of aeromethods in soil cartography is a question of methods which are not yet developed.

Methods for interpreting the soil cover may be used with success only with the application of principles of genetical soil science, laid down by V. V. Dokuchaev. Considerations of the interrelations between soils and other landscape components, as well as the use of comparative geographical method when analyzing aerial photographs opens big possibilities for interpretation of soil cover.

The use of genetical principle in interpretation makes possible a profitable use of aerial photographs not only for middle scaled but also for general soil survey work.

Our methodological investigations in different natural zones of the USSR on various photofilms showed that only the use of aerial photographs makes possible a compilation of detail and objective soil maps of big scales with a minimum expenditure of time for field work.

When using aerial photographs the field work begins with reconnaissance survey, when the natural relationships are found out and peculiarities of the photopicture of different landscape components determined. Then a preliminary soil map by means of stereoscopic interpretation of aerial photographs is compiled. At the same time the analysis is made of the photo tone, photo picture, dimensions, figures of soil contours traced, their situation as to the relief and surrounding soils. Soil contours traced on aerial photographs are plotted on aerophoto or land use plans. Then this preliminary map is checked in the field. Soil contours are documented by profiles and samples are taken.

Investigations have shown that the use of aerial photographs for detail soil survey is effective in all natural zones, for areas with virgin vegetation as well as on arable lands. The most effective is the use of aerial photographs for territories with a complicated and complex soil cover, which requires much work when plotting it on soil maps. To these territories belong the tundra zone, zones of dry and desertic steppes. The complex soil cover of these zones, bound with microrelief, induces a redistribution of moisture, easily soluble salts in dry steppes and correspondingly of vegetation, gives on aerial photographs an ununiform picture. By the design and coloring of this photopicture not only boundaries of such a complex soil contour can be traced but also the composition and percent of various soil components in this complex determined.

When compiling soil maps on basis of aerial photographs for dry steppe regions the volume of field work decreases 2-4 times.

When applying aerial photographs in the forest zone the volume of field work also decreases in many times. The accuracy of maps compiled increases considerably.

In steppe and forest-steppe zones especially effective are spring panchromatic aerial photographs. In this time of year the fields are not covered with crops and different soils, that differ as to coloring of the upper layer and moisture content give on aerial photographs various tones.

Interpretation of soils on aerial photographs is the more accurate the higher are the interpretation qualities of the aerial photographs. The interpretation qualities of aerial photographs can be improved selecting the best for this zone time for taking the picture and type of photofilm (panchromatic, colored spectrozonal and others).
INVESTIGATIONS OF SOILS IN THE FARMING SYSTEM OF THE UKRAINE

P. A. Vlasyuk

The territory of the Ukrainian Soviet Socialist Republic comprises about 60 million hectares. The correlation of agricultural arable land in relation to the whole cultivated area of the Republic makes up 78%; in some regions (the steppe) it makes up 88%. The percentage of the cultivated arable land in the Ukrainian SSR is one of the highest in the world.

Since 1956-1957 the Ministry of Agriculture of the Ukrainian SSR and the Ukrainian Academy of Agricultural Sciences have carried on soil investigations on a large scale. By 1960 such investigations had been carried out on an area of 28 million hectares, and by 1961 all arable land will have been investigated (47 million hectares).

As a result of these investigations soil maps (1:25000 or 1:10000) and charts, which will supplement data, will be compiled for every collective and state farm. These charts are as follows: the charts on which are shown soil areas with identical agronomic potentials; the charts of the planned and desirable hydrotechnical (irrigation, desiccation) or chemical melioration (liming, gypsum application); the chart of cultural practices for erosion control and protection of soil cover; the chart of the best cultural practices for raising the productivity of natural meadowlands. This gives data for the best utilization of the whole arable area of a given farm.

Besides the cartographic material every farm gets a monograph in which, in accordance with the adopted prospectus, is given the description of the soil cover and soil in relation to agricultural production. The data of the soil investigations are used by farmers for current and long-term planning of farm work, and especially for working out the farming system.

Efficiency and profitableness of the farm as a whole and also all recommended measures are taken into consideration in the farming system. In connection with this the following problems are being worked out: the organization of the territory; the working out of the structure of the arable area and crop rotations; land-reclamation; systems of soil cultivation; fertilizer systems; seed improvement; increasing yields of grain, forage, and other agricultural crops; fruit-growing, viticulture, berry plantations and control of the main pests and diseases of crops.

The elaboration of a farming system allows one to predict the yields of agricultural crops from 100 hectares of arable land and to make an evaluation of the land as the main factor in agricultural production. This evaluation is a criterion for comparing the results of the farm's activity both in the case of the farms being under equal economic and natural-historical conditions and for the state comparative characteristics of farms with different economic and natural-historical conditions.

On this basis the agricultural division into districts is built all over the Republic.
SOILS OF KAZAHSTAN AND DEVELOPMENT OF VIRGIN LANDS

U. U. Uspanov

Kazakhstan SSR covers a vast area of 276 million hectares, that is 12% of the whole USSR territory. The most part of it (9/10) is an arid plain situated in the steppe, desert-steppe and desert zones. In the eastern and southeastern parts of Kazakhstan the more humid mountainous areas are well traced.

The whole territory of the Kazakhstan lands (excluding big water surfaces) makes 269 million hectares. Between these in the steppe zone chernozems and chestnut soil along with solonetz (alkaline soils), solonchaks (saline soils), soloths and their complexes cover 71 million hectares (26.3%), among them: - in the subzone of chernozemic steppes with medium humidity - 25 mil. ha (9.2%) and in the subzone of dark chestnut soils of dry steppes - 46 mil. ha (17%).

The intermediate desert-steppe zone with light chestnut soils and their complexes covers 54 mil. ha (20%). Nearly half of the Kazakhstan territory - 127 mil. ha (48%) belongs to the desert zone, including desertic steppes on foothills. Here the brown, gray-brown soils, sierozems, sands, solonchaks, etc., are met. The mountainous areas with mountain-steppe, mountain-forest and mountain-meadow soils cover an area of 17.2 mil. ha (6.4%).

The Kazakhstan toilers solve with success the problem of agricultural development of their territory. Beginning from 1954 in Kazakhstan about 23 million hectares of virgin lands was developed. Preliminary soil survey work was conducted, the most fertile land, mostly in the chernozem and dark chestnut zones were found out and recommended for development. After the development of new lands the arable area in Kazakhstan increased more than three times.

To the end of 1958 arable lands in Kazakhstan covered 14.1%; old fallow lands 1.7%, pasture lands 80% and hayings 4.2% from the whole territory of agricultural lands. About 80% of all arable land is situated in the northern districts and regions, in the zone of chernozems and chestnut soils.

In Kazakhstan there are still undeveloped land suitable for agricultural production. At present the main problem is to utilize the arable lands in a right way and maintain the fertility of already developed soils, to raise the culture of agriculture and increase the yields of all agricultural crops. With this aim in mind the scientifically based agriculture systems as to natural-economical zones and districts of Kazakhstan are being elaborated.
A better solution of agricultural and economical problems in farming practice necessitates the elaboration of methods for appraising soils and evaluating lands. In our conception the evaluation of lands comprises a comparative evaluation not only of soil's quality, but of the total of natural conditions, affecting the methods of land utilization and the rentability of farms. The points (marks) of evaluation of soils and lands may differ considerably and that is of great importance for the farmer, who has a better orientation in the rational utilization and amelioration of his lands, to know all appraisement principles and not only its final result.

Principles

1. V. V. Dokuchaeov has shown, that the assessment of soils is to be based on a comparative evaluation of soil properties as they impartially affect soil fertility. Modern soil science provides data for realizing this first principle of evaluation. Yet for a detailed evaluation on a large scale the classification data are not sufficient. That is why in assessment tables concrete combinations of soil properties must be given.

2. Soil apprisement must not be retrospective (that is it must be founded on natural soil properties), but must reflect the situation achieved due to cultivation. The influence of natural soil properties in this process must also be considered. So the assessment tables must be different for different genetic soil types.

3. Methods for soil apprisement according to their properties must meet the principle of mutually determinant influences of soil fertility factors. Soils cannot be evaluated by a simple summary of separate properties.

4. Soils must be evaluated as to their adapted groups of agricultural crops. Then with the help of the average weight method, the soil fertility in a rotation may be evaluated further.

5. The yield data must be criteria for the correctness of assessment tables, compiled on the bases of soil properties. This was shown by Dokuchaev and Sibirtzev. The main point in the assessment enables one to forecast the value of normal yields and to establish the character of correlation between soil properties and yields.

Possibilities

Besides being the basis for different land use and rotational distribution of crops, the evaluation by the method proposed makes possible a forecast of yield dynamics depending on the change in soil properties foreseen in assessment tables. It enables one to plan the yields and to compare the industrial achievements after considering the qualitative soil differences. For cooperative farms it is a basis for correct calculations of differential labor payments.
Man uses and works with soils to produce things that will satisfy human wants. Soils alone produce nothing which, without human effort, will satisfy any human want. Production from a tract of land results from the combined effects of the soil, its climate, the things that man does, and the skill with which he does them.

The combinations of things that man does in order to grow and harvest plants on a tract of land we shall call management systems in contrast to management levels.

Management systems are defined in terms of inputs, the things that man does. They are the opportunities or alternatives that man considers in making his decisions about the use and management of his land.

Management levels are evaluations of the results achieved using various management systems in relation to specific objectives. These objectives or purposes of management are many and varied. They may be physical or economic. Once the purpose has been selected, the different levels can be defined relatively easy in terms of results achieved.

The productivity of a soil is the aggregate of the responses—quantity and quality of plants harvested—to all management systems. It is a very broad concept and a full statement of the productivity of a soil is a statement of the alternatives or opportunities which exist.

People make decisions about the use and management of their lands on the basis of what they believe would be the future production resulting from the alternatives that they consider. In order that their decisions can be the best possible ones, we need predictions of future production resulting from specific management systems which are based upon an evaluation of all relevant information. The philosophy of key or benchmark soils is to achieve that end.

The prediction of soil productivity, in common with many problems, involves two distinct and separate aspects. One is the making of predictions now based upon existing information. The other is the designing and conducting of research in order that prediction made in the future can be improved.

Predictions of soil productivity, such as those included in soil survey reports and economic studies, are usually for the next 10-20 years. They are the anticipated average results for a group of farmers if they used the stated management system.

If we want people to make the best possible decisions, we must do our part to make the best possible predictions of soil productivity.
For every kind of land classification, a good soil survey must provide the foundation. For a good soil survey, a good system of soil classification, world-wide if possible, is necessary. Only in this way the objective basis for a transfer or knowledge is guaranteed. This transfer of knowledge and of experience, scientifically and objectively performed, is the best way to promote efficient land use.

In the Netherlands a quantitative approach to Soil Suitability Classification is being made. This is done by teamwork, which is the only way to tackle this complicated research. The data are found by: (1) Systematic enquiries. (2) Systematic projects of trial harvests and yield estimates. (3) Crop-surveys and surveys of the vegetation of pastures on various soil types. Only well-farmed plots are included in these various investigations.

The quantitative data thus obtained are combined in such a way as to demonstrate the practical differences between various soil types for the people who use the soils, particularly for the farmers. This is done by means of a budgetting technique, according to the following formula:

\[ S_A = (R.Y) \cdot E_1 - R \cdot (F + O) \cdot E_2 \]

in which formula

- \( S_A \) means "rate of suitability" of soil type A,
- \( R \) means "Rotation" (i.e. acreage of each crop in percentages of the total acreage of the farm),
- \( Y \) means yield of each crop in kg/ha on soil type A,
- \( F \) means fertilizers used for each crop on soil type A,
- \( O \) means all other costs of farming, excepting fertilizers.
- \( E_1 \) and \( E_2 \) are economic parameters, valid for a certain technical and economic situation.

The means of calculation of this formula is given by using normalized monetary units, the significance of which is determined by the choice of \( E_1 \) and \( E_2 \). \( S \) may be given either in terms of these normalized monetary units or in a relative scale, e.g. from 1 to 100. The formula actually has the character of a vectorial formula. This vectorial formula is also accessible to solution by means of the linear programming technique. In this way the modern means of "Operations Research" may be a very valuable tool for promoting the most efficient use of soil classification and soil survey.

Apart from the practical results for agriculture a better insight is gained into the limitations of the soil survey, e.g. with regard to the extreme variability of the yield data on each separate soil type. In arable farming conclusions can only be made if the whole rotation and all cost factors are taken into account.

Soil suitability, apart from the economic parameters, is determined by the following factors, all dependent on characteristics and qualities of the soil type: (1) yield; (2) costs of producing this yield; (3) quality of the product; (4) risk of production; (5) soil pattern (cf. KELLOGG, 1941). Only part of these has been studied. Research on the importance of risk has been reported at the VIth Congress (VINK, 1956). The soil pattern will get more of our attention in years to come.
Considerable attention is being deservedly devoted of late to the problem of subdivision into soil districts, especially in connection with the planning and specialization of agricultural production, according to the natural and economic zones of the USSR.

It is quite obvious that mountain areas with their greater variety of natural conditions (including the soils) differently expressed vertical zonality require more detailed schemes of dividing the soils and the entire complex of natural conditions into districts than do the level areas.

Taking into consideration the genetic and agricultural peculiarities of the soils, the nature of their utilization, measures for amelioration, etc. it is necessary to divide the highlands into vertical zones and these into subzones and districts. As the agricultural division is done in a relatively detailed scale subdistricts and even microdistricts can be traced.

This subdivision is based on the soil geomorphological, hydrological, climatic and, in connection with them, agricultural peculiarities of the districts in the sense of their present and possible utilization in agriculture and measures for increasing soil fertility.

Georgia's geographical location, greatly dissected surface and other factors condition a big variety and peculiarity of natural conditions and, accordingly, soils.

Soil regions of Western, Eastern and Southern Georgia and within their limits subregions, vertical soil zones, 48 soil districts and 55 subdistricts are distinguished in the Georgian SSR.

More detailed work is being completed for all the administrative areas of Georgia. This being a basis for the schemes of further division into agricultural microdistricts. More detail work, according to this scheme is being done for individual state and collective farms.

As indices of the agricultural characteristics of soils and the concomitant conditions we give:
1. The name and characteristics of the soil
2. Character of the surface (including the height of the terrain)
3. Hydrological conditions
4. Extent of soil erosion
5. Available irrigation
6. Nature of the land and existing crops
7. The possible subsequent utilization and the crop
8. Measures aimed at – (a) cultivation of the soil, (b) application of fertilizers, (c) controlling erosion of the soil, and (d) melioration.

According to the aforesaid scheme, we have compiled a characteristic for all the types, subtypes and species of Georgian soils and all the individual soil microdistricts.
CLASSIFICATION BINAIRE DES SOLS EN FONCTION DE LEUR VALEUR

M. Jean-René Desaunettes

PRINCIPE. Le potentiel de productivité d'un sol est fonction de sa capacité totale de retention, qui est elle-même le produit de deux valeurs essentielles:

1. La profondeur utilisable, et 2. La capacité de rétention unitaire, exprimée sous la forme de "Dose pratique maximum d'arrosage unitaire", et donnée par la formule classique: $D = 0,3 X \Delta a X H$, où $\Delta a$ est la densité apparente du sol, et $H$ l'humidité équivalente de la terre fine.

En appelant cette valeur $D$: "Capacité de retention" au sens large, ou $Cr$, et en donnant à la profondeur utilisable du sol le symbole $h$, le potentiel du sol est donc représenté par $h X Cr$: Potentiel du sol $= h X Cr$. Malheureusement, la connaissance de cette capacité potentielle des sols n'est pas suffisante dans sa forme brute pour permettre son interprétation, et les qualités culturales des sols dépendront de la valeur des deux variables: $Cr$ et $h$ dans l'expression $h X Cr$.

REALISATION PRATIQUE. La Profondeur utile du sol et la Capacité de retention sont divisées en un certain nombre de classes numérotées de 0 à 9, les chiffres impairs étant réservés aux sols homogènes (profondeur constante et $Cr$ variant peu le long du profil), les chiffres pairs caractérisant les sols d'épaisseur irrégulière ou de $Cr$ variable.

Les valeurs adoptées pour chaque classe n'ont rien d'absolu et doivent être adaptées au cadre des études.

UTILISATION DE LA CLASSIFICATION. D'une manière générale, la multiplication des deux chiffres impairs donne le potentiel de production du sol, et la repartition des deux chiffres indique la façon d'utiliser ce potentiel. Les normes d'utilisation dépendent des régions considérées et devront être établies pour chaque cas particulier.

Cas spéciaux.

1. Sol forme sur matériau complexe. Quand le profil du sol comporte deux niveaux tranches dus à la nature de la roche-mère, il faut utiliser un couple de 2 paires de chiffres.

2. Sols salés. Il est nécessaire de distinguer deux cas:
   a. Sol inutilisable dans l'état actuel et dont la profondeur utile dépend des travaux de dessalage. Dans ce cas, on remplace le chiffre correspondant à la profondeur par la lettre S. Exemple: S9: sol salé à forte rétention, inutilisable actuellement.
   b. Sol utilisable dans l'état actuel sur une certaine épaisseur (indiquée par le chiffre), mais qu'on peut améliorer en l'approfondissant par des travaux de dessalage: on met la lettre S après le couple de chiffres caractérisant le sol. Ex: 36 S. On peut aussi distinguer les sols salins et les sols à alcalis.

3. Sols Exohydromorphes. La même distinction est à faire avec la lettre H entre les sols hydromorphes inutilisables dans l'état actuel (profondeur utile nulle), et ceux où la profondeur utilisable pourra être augmentée à l'aide du drainage.

4. Sols Endohydromorphes. On ajoute la lettre T qui indique que l'amélioration souhaitée ne sera possible que grâce à des techniques plus complexes.


CONCLUSION. La Classification Binaire est basée sur 2 caractéristiques fondamentales du sol: la profondeur utile et la capacité de rétention. Ces deux notions suffisent pour définir entièrement le valeur d'un sol et les modalités de son utilisation dans le cas général.
ANCIENT FARMING AND EVOLUTION OF SOILS

A. N. Rozanov

The first investigators N. A. Dimo and M. A. Orlov came to the conclusion that a regular sedimentation on the irrigated fields of deposits from irrigation waters and application of earth-like fertilizers result in peculiar "agro-irrigation layers" by thickness of 1-2 m and more being formed over the natural soil cover. These layers are distinguished by their greyish coloration, homogeneity in texture and constitution, absence of carbonate concretions, and by inclusions of coal pieces, fragments of earthen ware and bricks, bones, etc. brought together with earth-like fertilizers.

The humus content in the agro-irrigation layers makes some 1-1.5% in its upper parts and 0.3-0.8 in its lower parts. For all that, due to the thickness of the layers the total humus and nitrogen stocks in the soils of ancient irrigated-farming cases are far greater compared to arid and virgin soils. The continuous irrigation brings about marked changes in texture. The agro-irrigation layers are usually characterized by a high carbonate content. The irrigated soils were also found to be active biologically and abundant in the nutrient elements.

The soils radically changed in the course of prolonged irrigation are called: "cultivated-irrigated", "old-irrigated", "ancient-irrigated" soils. The analogous soils occur in the cases of ancient irrigated farming in China, Mesopotamia and Persia. Some of the essential peculiarities of the old-irrigated soils are accounted for by the bio-climatic conditions of soil formation. Thus the old-irrigated soils of the sierozem zone of Central Asia retain the low humus content peculiar to sierozems, nearly the same composition of humus substances, small exchange capacity and high carbonate content. If the irrigation is stopped they are converted into sierozems.

The research conducted in the areas of ancient non-irrigated farming is also indicative of the important role played by man's activities in soil formation. For example, in China the natural soils of the Loess Plateau have almost completely disappeared as a result of 2-4 thousand old crop farming. They are now buried under the humus accumulated layer of anthropogenic origin as a result of continuous application of earth-like fertilizers. The thickness of the layer may be 30-50 or even as much as 70-80 cm. So the soils of ancient non-irrigated farming regions have a three-part profile:

1. Humus-accumulative layer
2. The charged part of the natural soil
3. Natural horizons of the natural soil.

The humus content in the arable layer of humus accumulative horizon is sometimes more than in the horizons A', A'' of the natural soil.

The soils so radically changed by continuous cultivation deserve to be distinguished under a special name of "old or ancient arable lands." Old arable lands are considered to be subtypes of natural soils, such as sierozems, heilutu, grey-cinnamonic, etc.
PHYSICAL MATURITY OF PRINCIPAL SOIL TYPES OF THE
ZONE UNDER IRRIGATION IN CENTRAL ASIA

S. N. Ryzhov and N. I. Zimina

It is only in a definite interval of moisture that the soil can be
tilled most advantageously, with the minimum of tractive efforts being
consumed and stable aggregates formed. In this interval the soil after
ploughing yields the maximum quantity of small-clod structure, 1-10 mm
in diameter. With higher moisture content the soil acquires cohesion
properties at the expense of crumbling properties, whereas with lower
moisture content the soil yields large clods and dust. The most advan­
tageous state of soil moisture content as regards its structure is known
as physical maturity or simply maturity.

As a result of a more extensive study of the basic soil types in the
zone under irrigation in the Central Asian Republics we came to the final
conclusion that in all the cases the optimum moisture content during
cultivation and the aggregation moisture content in high-carbonate
soils are either equal to or very close to Atterberg's lower limit of
plasticity. For example, for the typical heavy-loam sierozem of the
Ak-Kavak Experiment Station the aggregation humidity is 18-19%, optimum
crumbling humidity - ditto, and the lower limit of plasticity - 18.2%;
the aggregation humidity of light-colored average-loamy sierozem of the
Goldnaya Steppe ranges from 18 to 20%, the optimum crumbling humidity -
18-20%, and the lower limit of plasticity - 18.8%; the aggregation
humidity of the sandy-loam takyrs (cracked hard soils of dry water-
collecting depressions) in the Kara-Kalpak Autonomous Republic equals
14-15%, its crumbling humidity - 15-16% of the weight of the soil assayed.
For most of the soils of medium and fine texture the humidity of crumbling
and structure-formation ranges from 15 to 20%.

The state of physical maturity for one and the same soil species
ranges within a narrow humidity interval, within the limits of 2-3%, e.g.
16-18%, 18-20%, 15-18%, etc.

The physical maturity of aggregation humidity chiefly depends on the
organic matter content, texture, and the state of cultivation of the
soil. The soils regularly enriched by organic fertilizers have an in­
creased aggregation humidity. For example, on a test plot of the Ak-
Kavak Experiment the aggregation humidity of the soil from the un­
fertilized version of the test was 18-19%, and from the version regularly
(30 years) fertilized with manure ranged from 20 to 22%.

By the data collected we may establish the optimum humidity for
ploughing, harrowing and sowing of the most widespread soil types in the
zone under irrigation in Central Asia.
ADVANCES IN SOIL PHYSICS

L. A. Richards

Young branches of natural science often pass through a descriptive stage which is concerned with qualitative observations and unrelated empirical data. As regularities become apparent, underlying general principles are formulated and tested, and comprise a basis for a more mature and quantitative stage. Soil water is a subject matter branch of Commission I that ties in with the traditions of physics because energy and its transformations have recognized pertinence. This branch has moved along in the maturing process and has become appreciably more quantitative since the last Congress. Descriptive theory for liquid flow of water in unsaturated soil under isothermal conditions has advanced appreciably. Two approaches are favored. The older, in which the flux is assumed to be proportional to the hydraulic gradient, has been successfully applied for several problems having agricultural significance. Progress here has been based in part on improved experimental techniques for evaluating the proportionality factor in the flow equation, namely, the capillary conductivity function. There is still need for more convenient methods for experimentally determining both the conductivity and the retentivity functions for soil at field structure.

The nonlinear diffusion method also has been refined and successfully employed. One of the useful applications has been the clarification of the concurrent effects of electrolyte concentration and exchangeable-sodium status on soil structure as evidenced by effects on soil-water diffusivity.

The effect of temperature on soil-water phenomena is coming under investigation, both with regard to water transport rates and to the intensity of retention. This approach will help to identify and evaluate the mechanisms involved in water transport. Consideration of steady-state phenomena in a closed soil system with a temperature gradient forces the conclusion that the partial specific free energy and other characteristic functions from classical thermodynamics are unsuited for describing the dynamics of water transfer in soil. This inadequacy is further emphasized if imperfect, semipermeable membranes are involved, as in plant roots. We can expect an accelerating interest and effort in the examination of the microphenomena of the adsorbed phase of the soil solution. Agriculture is based on a water film ranging in thickness from 6 to 20 monomolecular layers on the surface of the soil. Crops cannot grow when films are thinner than this and in most soils thicker films are present only during soil wetting processes and have short duration.

The solid phase of the soil, i.e., the soil matrix, has a strong attraction for water. Matric suction is a measure of this water binding action and is the minimum pressure reduction across a permeable membrane required to extract water from soil. Its measured value depends mainly on the thickness of the water film. It depends also on the ambient temperature, the ambient pressure, the nature of the surface of the matrix, and the history of the soil. Under history would be included structural and biological status and recent past changes in the water and solute content.

The soil-water system is dynamic. Under the influence of genetic processes, the essential characteristics of the matrix must be considered as being transient. Because of the numerous chemical and physical gradients impressed on the soil profile by the environment, it is likely that true equilibrium seldom exists between even nearby soil particles. On the other hand, because of the short distance through the water film
from the matrix to the gas interface, it may well be that thermodynamic
equilibrium substantially does exist across the adsorbed film phase and
that a relative pressure measurement of water in the gas phase reliably
indicates the energy status of water in the two adjacent phases.

In addition to water binding by force actions from the matrix, the
status of water in the adsorbed film is conditioned by solute. The
water binding effect of solute restricts water uptake by plant root
membranes. The total suction of soil water, matric plus solute, is
indicated by the relative pressure of water in the adjacent soil air.

Under favorable laboratory conditions, it is possible by means of
thermocouple psychrometers to measure the relative pressure of water
vapor with an accuracy of about one or two parts in one hundred thousand
in the neighborhood of saturation. When the vapor measurement is con­
verted to matric or total suction, this corresponds to an error of about
16 millibars. It is evident that vapor pressure measurement will play
an increasing role in the investigation of the soil-water-plant system.
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Room A - Union Theater
Room B - Union Ballroom
Room C - Wisconsin Center Auditorium
Room D - Wisconsin Center - Room 210

Morning sessions begin at 9:00 a.m. and end at 11:45 a.m. A general session for all commissions is held daily in Room A at 1:30 p.m. Afternoon sessions begin at 2:45 p.m. and end at 5:30 p.m.