CONTRIBUTIONS OF SOIL ORGANIC MATTER TO PRODUCTION POTENTIAL OF SOILS AND SOME PROPOSALS FOR PRACTICAL APPLICATION

Wolfgang FLAIG

Annex II

to the report of W. FLAIG

9 Lectures about: Contributions of soil organic matter to production potential of soils and some proposals for practical application.

delivered at Nuclear Research Laboratory, Indian Agricultural Research Institute, New Delhi, from 12. July to 18. September 1973.

Country	:	India
Project	:	Ind-68-589 - Nuclear Research in Agriculture
Name of Expert	:	Prof. Dr. W. Flaig
Field Report No.	:	Final Report
Period	:	5 July - 30 September 1973
Post Title	:	Soil Chemistry (Soil Organic matter)
Date	:	28th September, 1973

CONTRIBUTIONS OF SOIL ORGANIC MATTER TO PRODUCTION POTENTIAL OF SOILS AND SOME PROPOSALS FOR PRACTICAL APPLICATION

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1973

Preface

The increase of yield/ha is important for the food production of Indian Population. For this purpose firstly high yielding varieties of rice, wheat and other crops were bred. These demand a higher quantity of mineral fertilizers. Fertilization alone does not allow the realization of the full genetical potential of cereals. The inorganic ions of the fertilizers enhance also microbial activity. The microorganisms use the carbon from soil organic matter as source for energy and reproduction. As a consequence of decrease of soil organic matter unfavourable processes in soil, the substrate for production occur, which cause a reduction in plant production. Therefore an increase of yield by fertilization alone is limited.

Another way to overwhelm the biological border for the use of the genetical potential of cereals is to utilize the effect of bioregulators on plant metabolism, such as CCC, "Cycocel" to increase the resistance against lodging of wheat. There are some other substances in soil organic matter, which have bioregulating effects under unfavourable growth conditions. This influence of soil organic matteron yield is well known by the farmers as "humate-effect".

Therefore, it is evident, that special procedures for maintaining a critical status of soil organic matter should be followed. More research about humus is necessary. An intensive cereal production is then economical only, when yields are always maintained at a relatively high level. One should try to minimize the yield depressions by appropriate procedures.

The lecutes are an introduction into the problems. The transfer of results of basic research into practice are mentioned and the experiences about the utilization of new findings are summarized.

I have to thank Mr. M.S. Sachdev (M.Sc.) for his indefatigable help, for the revision of the lectures and for compiling the references.

Wolfgang FLAIG

New Delhi, 29. September 1973

Content

GENERAL LECTURE

MODERN ASPECTS IN HUMUS RESEARCH FOR PLANT PRODUCTION

Summary

The way of economical thinking at present demands from the farmer to produce a high yield/ha by the use of mineral fertilizer. But an increase of nutrients in soil enhances also activity of micro-organisms. These use the carbon of soil organic matter as a source of energy. Therefore carbon content decreases and with that unfavourable processes occur, which have a negative influence on plant production. By this reason research about humus must be strengthened. New tools and new methods allow us now-a-days to promote basic work to get the causal connections in the system soil-plant in relation of soil productivity and yield stabilisation.

The direct and indirect effects of constituents of humus are not only different by chemical composition but also by their physical properties. Alterations in soil structure with all their consequences occur and biochemical influences on metabolism of organisms living in soil can be observed.

The direct effect of constituents of soil organic matter, the uptake of compounds through the roots of plants can be caused for instance by phenolics, which are formed by lignin degradation or synthesised microbially. Their transformation

in the plant can be followed by different labelling with carbon-14. To go in more details it has been worked with plant cell suspension cultures. The repeatedly observed yield increasing effect of phenolics or of their corresponding quinones may be explained by their ability to form complexes with alkali ions. By that different metabolic pathways in the cells are changed; these substances have properties of bioregulators.

The results of the mentioned basic research work can be utilised for practical applications.

One of the first steps in this direction is to determine similarities of the humic systems in different soils under different climatic conditions to be able to evaluate the contribution of soil organic matter to plant production.

Furthermore a slow releasing organic nitrogen fertilizer was synthesized from lignin containing waste lignors of pulp and paper industries - simultaneously a contribution to environmental protection. Not only the adoption of plant nutrition with nitrogen according to the needs but also the physiological effect of the phenolic lignin degradation products lend out new possibilities of this nitrogen fertilizer.

The history of plant production learns us, that besides the means, fertilization, breeding, plant protection and soil management, which increased yield upto now, in future also bioregulators must be used, which have an stablising effect on yield production under abnormal environmental condition.

From economical point of view it is important to minimize the yield depressions, which are below a long-term average, by substances with bioregulating effects.

GENERAL LECTURE

MODERN ASPECTS IN HUMUS RESEARCH FOR PLANT PRODUCTION.

To start with a lecture about the importance of soil organic for plant production is a reason to think over, what does agriculture do at the moment in this branch.

Agriculture makes enormous efforts to produce as high yields per ha as possible.

The dependence of the income on the fertilization with mineral fertilizers may be explained by an example from Germany (Weztzel u. Rodewyk, 1970).

Tab. 1 : Dependence of income on increased mineral fertilization (figures in paranthesis are equivalent of DM in rupees)

Mineral Fertilizer (input in DM/ha)	Yield of wheat (q/ha)	Income (DM/ha)
183 (457.50)	38.7	744 (1850.00)
203 (507.50)	40.6	779 (1945.50)
247 (617.50)	43.7	912 (2280.00)

An expense of 183-Deutsche Mark on fertilizers, produces a yield of wheat of 38.7 quintals/ha. This yield corresponds an income of 744 -Deutsche Mark/ha.

An additional expenditure of 64,-Deutsche Mark increases the yield upto 43.7 quintals/ha and increases the income to 912,-Deutsche Mark/ha. A more expense on fertilizer of 64,-Deutsche Mark increases the income upto 168,-Deutsche Mark per ha.

Higher fertilization was an additional profit of 104-DM for the farmer. This example shows to which extent a higher utilization of fertilizers has an effect for increasing production and income under the same condition.

These are the agricultural economical considerations now a days, from which the administrators draw their conclusions for food production.

The management is done irrespectively more or less what happens with the soil as the base for plant production. The amount of fertilizer is increased more and more and nearly no body thinks about the fact, what it means that upto 900 kg of a mixture of salts are distributed every year on the surface soil (2,250,000 kg) which corresponds to a concentration of 0.04 per cent or in average a concentration of 0.12 per cent salts on the colloidal system of the soil.

The higher concentration of inorganic nutrients, the higher activity of microorganism, which use the soil carbon as a source of energy for replication as much as possible. The equilibrium between formation and decomposition of soil organic matter is disturbed. The content of soil organic matter decreases and many alterations of physical and chemical properties of soil constituents occur, whereby a negative influence on the potential of soil for yield formation is caused. Some of the alterations cannot yet be handled, so for instance an increasing erosion, decreasing soil productivity, and therefore higher expenditures are necessary to keep the level of production. The present management of plant production continued for a longer time means "Rich fathers and poor sons" ; soil becomes exhausted.

One of the important factors of soil productivity is soil organic matter even, if its content in soil is low. The contribution of the inorganic part of the soil and in addition the contribution of mineral fertilizers are known. The effect of soil organic matter on soil productivity must be more elucidated, that it is perhaps possible, to manage this effect by man.

For the explanation of the subject here, some processes during humification of dead plant material will be summarized at first.

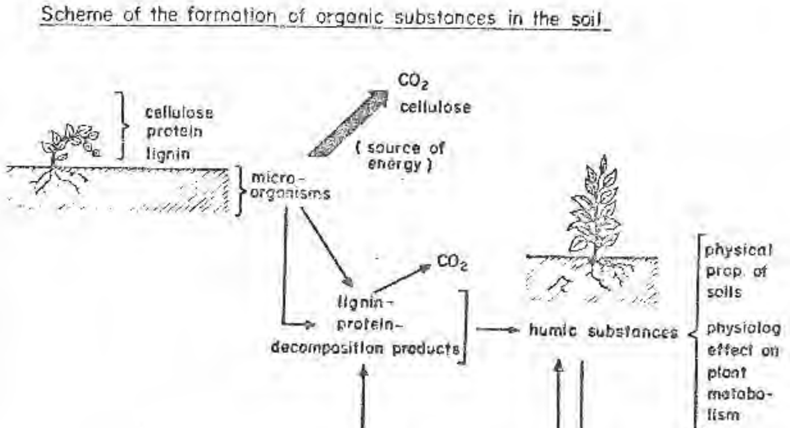


Fig. 1: Scheme of formation of soil organic matter.

The main constituents of the plants are cellulose proteins and lignin. The cellulose is used by the microorganism mainly as a source of energy and degraded to carbondioxide. A part of the cellulose as well as the protein serves for formation of the mass of microorganism.

Lignin is decomposed relatively slowly. Its transformation products react with the decomposition products of proteins to humic substances. The humic substances have an influence on physical properties of soil. They are an important factor for stabilization of soil structure. Otherwise they can have partly an effect on plant metabolism after uptake by the roots.

Soil organic matter itself is not stable, finally it decomposes to carbon dioxide, water and ammonia. The nitrogenous organic compounds in soil are slow releasing nitrogen sources for plant production. According to the present knowledge about soil organic matter, the formation of humic substances can be summarized as follows:

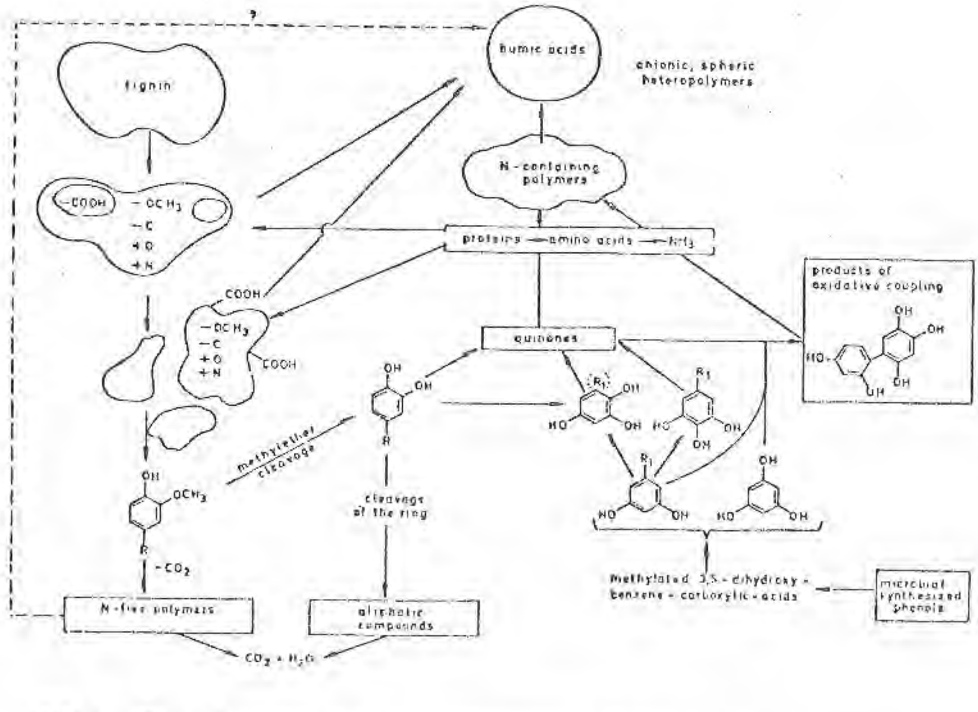


Fig. 2: Scheme of formation of humic substances.

There are mainly two sources of phenols in the soil which participate in formation of humic substances. Lignin is degraded to smaller particles by reactions at the functional groups. Lignin, changed in its properties by oxidative degradation upto low molecular weight phenols, reacts with degradation products of proteins to form dark coloured humic substances. The second source of phenols, the microbial synthesized phenols, react also after oxidative transformation with the protein degradation products to form coloured substances similar to humic acids.

During the oxidative processes also coupling reactions occurs, between lignin derived or microbial synthesized phenols.

By degradation of naturally occuring high molecular weight substances or condensation of degradation products, high and low molecular weight organic substances are always present in the soil.

Tab. 2: Division of substances in soil organic matter according to their effect on plants.

Soil Organic Matter

high molecular weight ⟵⟶	low molecular weight
mol. weight > 10^4	
Carbohydrates, Uronides, Nucleic acids } Linear colloids	Hydrolysis products and degradation products by oxidation
Proteins, Lignins, Chitin, Humic acids } Spheric colloids	Metabolites of organisms
	Fractions of fulvic, hymatomelanic acids

Indirect effects

Alteration of physical properties of soils	Participation in chemical reactions in soil

Direct effects

None	Influence of metabolism of organisms

The linear and spheric colloids alter the physical properties of the soil according to their chemical composition and give an indirect effect on plant metabolism, because high molecular weight substances are normally not uptaken by the plants.

Low molecular weight products formed by hydrolysis or oxidative degradation are the main constituents of the fractions which are called fulvic and hymatomelanic acids. These substances take part in chemical reactions of the soil. Some of them have a direct effect on metabolic processes of organisms. We may differentiate roughly between direct and indirect effects.

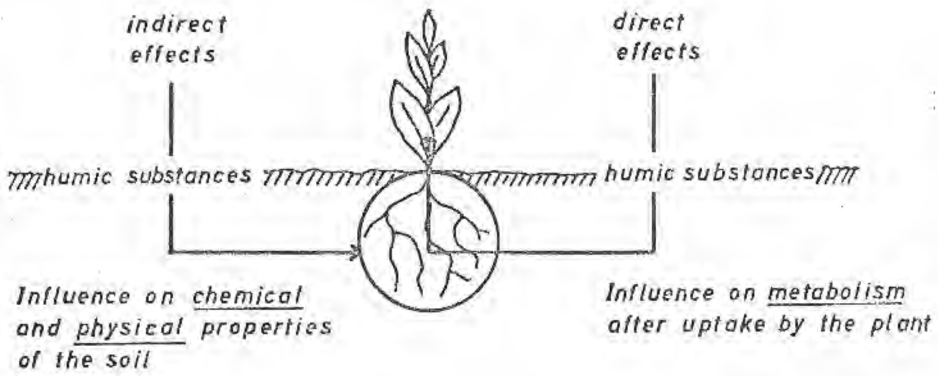


Fig. 3: Scheme of possibilities of influence of humic substances on growth and yield of plants.

Direct effects are such, by which the influence on plant growth is directly connected with the uptake of organic substances by the plants. The indirect effects change the environment of the plants and influence in this way the growth.

Some examples will be given about indirect effects of soil constituents on plant production.

We are interested in the interactions between colloidal soil constituents and organic compounds of the soil. For this reason, we made physico-chemical investigations with high molecular weight fractions of soil organic matter.

Humic acids isolated from chernozem aggregate or disaggregate according to the conditions.

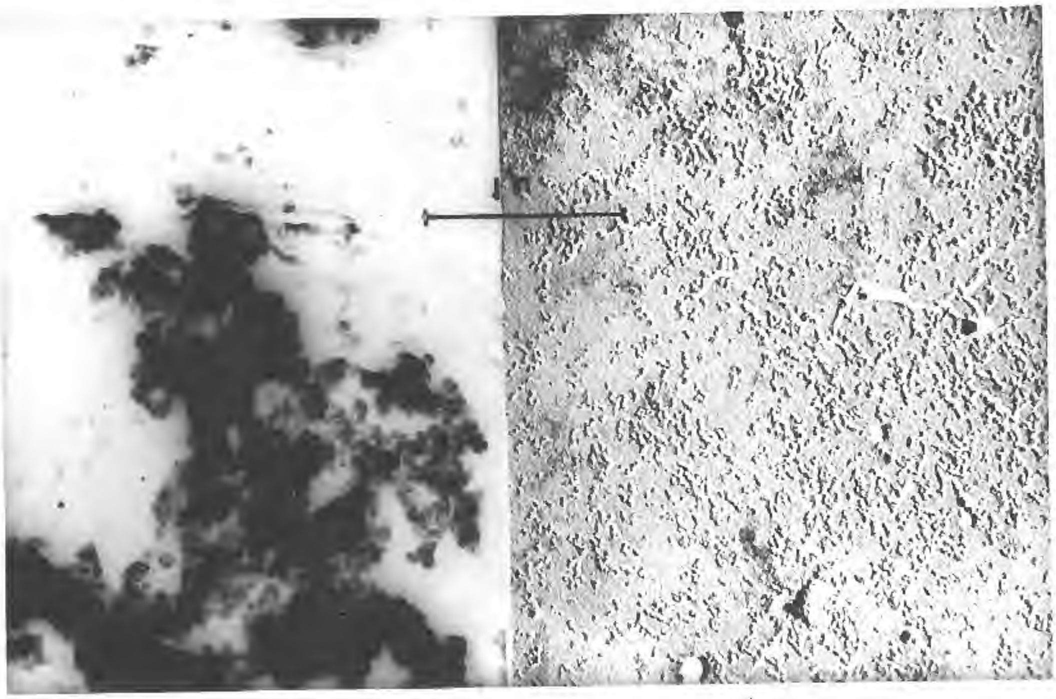


Fig.4: Humic acids in acid or alkaline solutions.

Highly purified humic acids come in acid solution to a ramified structure and form simultaneously coacervates, which means that several humic acid particles are covered with common water layers.

Humic acids are dispersed in alkaline solution to nearly single particles with a diameter of approximately 80 Å.

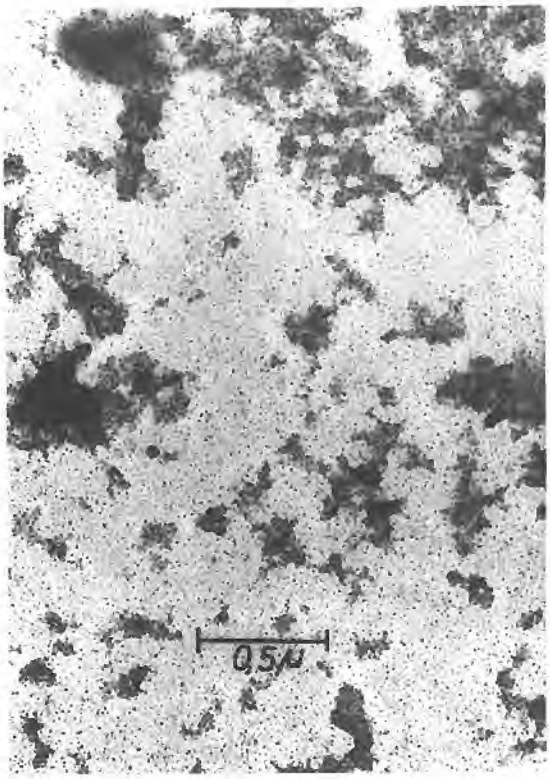


Fig. 5: Humic acids (pH 3.5) treated with ultrasonic.

As an example of the alteration of the hydration shell an electron microscopic picture of humic acids treated with ultrasomic at pH 3.5 is shown; the hydration shells are diminished and the electron optical density of the particles is increased.

Aggregation and disaggregation of humic acids due to the ionic concentration and pH could also be shown with ultra centrifuge.

Tab. 3: Effect of pH on sedimentation (S_{20}), diffusion (D_{20}) particle weight ($M_{S,D}$), particle diameter (2 r) and the friction coefficient (r/f_o) of humic acids in water and in 0.2M NaCl suspension.

Fraction of humic acids							serumalbumine (horse)
pH =	4.5		5.0	5.5	6.0		7.3
	I	Ia	II	III	IV	IVa	
	0.2 M NaCl without	with			0.2 M NaCl without	with	with 0.2 M NaCl
$s_{20} \cdot 10^{-13}$	2.01	4.71	1.77	1.53	1.38	4.46	4.46
$D_{20} \cdot 10^{-6}$	3.45	0.65	4.21	4.32	5.66	0.48	0.61
$M_{s,D}$	4850	60,400	3500	2950	2050	77,000	70,000
r (Å)	47	71	43	40	38	69	
f/f_o	1.1	1.2 1)	1.1	1.1	1.0	1.5 1)	1.27

$$s_{20} = \frac{1}{\omega^2 . t} . \ln r/r_a \qquad M = \frac{R . T . s_{20}}{(1 - V^* \rho) D_{20}} \qquad f/f_o = \frac{1}{\eta} \left[\frac{R^2 . T^2}{N_L^2 . D_{20}^2} . \frac{(1 - V^* . \rho)}{162 . V^* . s_{20}} \right]^{\frac{1}{3}}$$

$$D_{20} = \frac{F^2}{H^2 . 4\pi . t} \qquad r \text{ (radius)} = \left[\frac{9 . \eta}{2 (\rho_1 - \rho)} . s_{20} \right]^{\frac{1}{2}} \qquad f/f_o{}^{1)} = \left[\frac{1 - V^* . \rho}{D_{20}^2 . s_{20} . V^*} \right]^{\frac{1}{3}} . 10^{-8}$$

ω = angular velocity
F = area, H = height
V^* = partial specific volume
η = viscosity of solution
ρ = density (solution and solvent)
N_L = Loschmidt number

1) corrected for the amount of salt added

Not going in details, I will only draw your attention to two facts.

With increasing pH value, the molecular weight of electrodialysed humic acids decreases from about 5,000 to 2,000 but increases in the presences of 0.2M NaCl - a salt in a concentration of about 1% - from 60,000 to 70,000. These differences lastly are affected by the primary charge effect of the particles. Electron neutrality of the suspension is caused by the addition of sodium chloride.

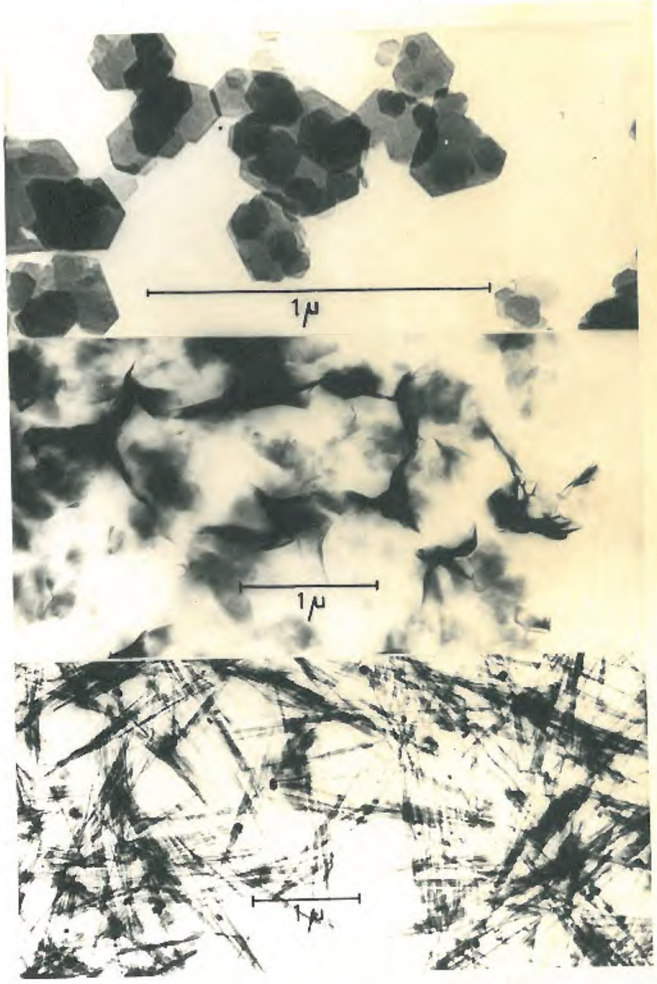


Fig. 6: Electron microscopical picture of kaolinite, montmorillonite and attapulgite.

Alone by the different morphology of clay minerals such as kaolinite, attapulgite and montmorillonite, it can be concluded that the structure of soil is influenced according to the quantity of one or the other clay mineral in the soil.

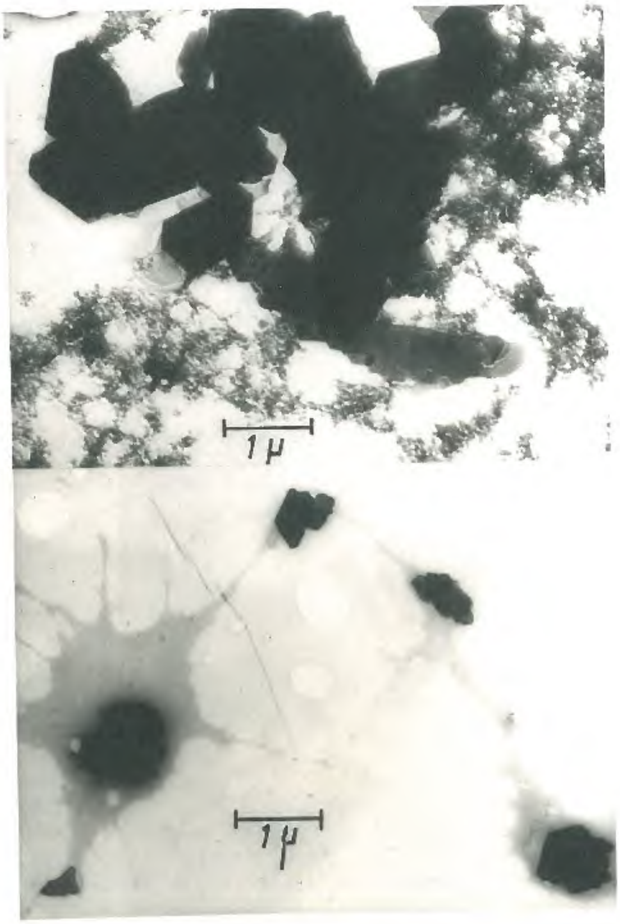


Fig. 7: Interactions between spheric and linear colloids with kaolinite.

Also we investigated the interactions between clay minerals and high molecular weight organic substances from the soil. Electrodialysed humic acids as spheric colloids do not interact with kaolinite. Both particles have a negative charge. In the case of polyuronic acids, a connection between the particles occurs due to the filamentous molecular structure of this linear colloid.

Recently we studied the activity of clay minerals on synthesis of organic compounds by microorganisms in connection with formation of humic substances.

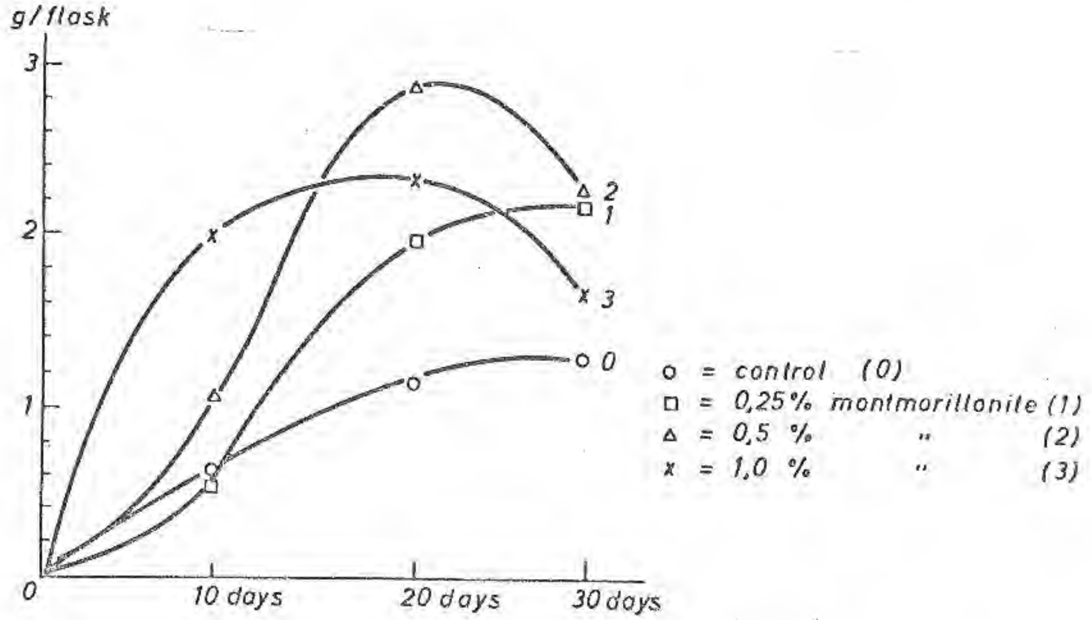


Fig.8: Effect of different quantities of montmorillonite on the formation of mycelium Epicoccum nigrum in stand culture (Filip et al., 1971).

Upto 20 days the dry weight of mycelium of Epicoccum nigrum increased by addition of montmorillonite as shown in the graph. By further investigations, it was found that the production of humic acid like substance is also increased. According to our investigations, we know, that these are formed from phenols which are synthesized by this fungus

Experiments in which the montmorillonite was enclosed in a dialysing tube in the culture solution, resulted also to higher production of humic substances. By X-ray investigations of the montmorillonite, it can be concluded, that the increase of formation of humic acid like substances is caused by sorption of low molecular weight compounds on montmorillonite. The basic reflection of this clay mineral is changed during increased production of humic acid like substances.

This experiment leads to others which are concerned with physiological effect of humic substances on growth of organisms.

By many publications, it is well known that fractions of humic substances can have a favourable influence on plant metabolism. To be able to decide which fraction of humic substances - low or high molecular weight ones - are active in these processes, the following experiment was made.

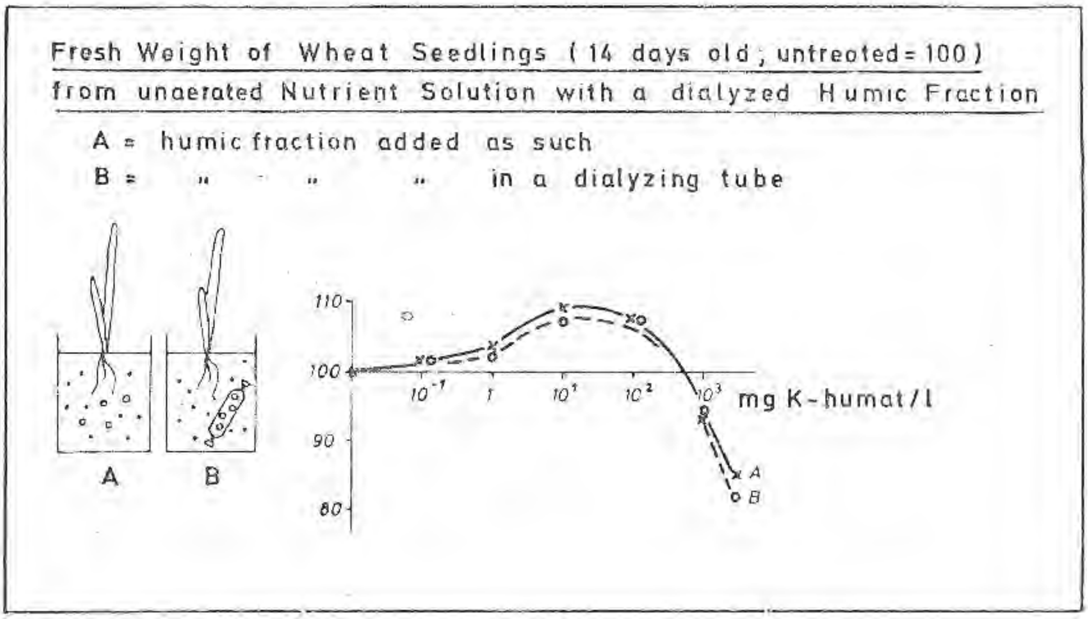


Fig. 9: Fresh weight of wheat seedlings (14 days old, untreated = 100) from unaerated nutrient solution with a dialyzed humic fraction (SÖCHTIG and HARMS, 1971).

A total humic fraction, extracted with potassium hydroxide from soils, was added to an unaerated nutrient solution in one case directly, in the other enclosed in a dialysing tube.

Dependent on the concentration, these substances influenced the fresh weight of wheat seedlings. Both the variances gave the same curve of effect. The conclusion is that only low molecular weight substances can have a direct influence in plant growth, because only low molecular weight parts of the humic substances can penetrate the membrane.

As it has been mentioned in the Introductory Lecture many authors have found that fractions of humic substances, increase utilization of normal doses or such high doses of nitrogen which are toxic for plants. The over doses of nitrogen become in this case effective for higher plant production.

For explanation in biochemical sense it can be assumed that :

1. Soil organic matter acts as a slow releasing nitrogen source and causes better distribution of nitrogen availability;
2. Physiologically active substances from soil organic matter influence plant metabolism.

Here mainly the second problem will be discussed.

According to basic researches, the phenolic compounds which can be isolated from the soil may be one of the types of physiologically active substances. The main source of the phenols in the soils are lignins, microbial synthesized phenolics or phenols from plants. The further discussion will be restricted mainly to phenolic degradation products of lignin.

<u>Phenols occuring in soils and their uptake transport and transformation in plants.</u>

Many lignin degradation products can be found in soils

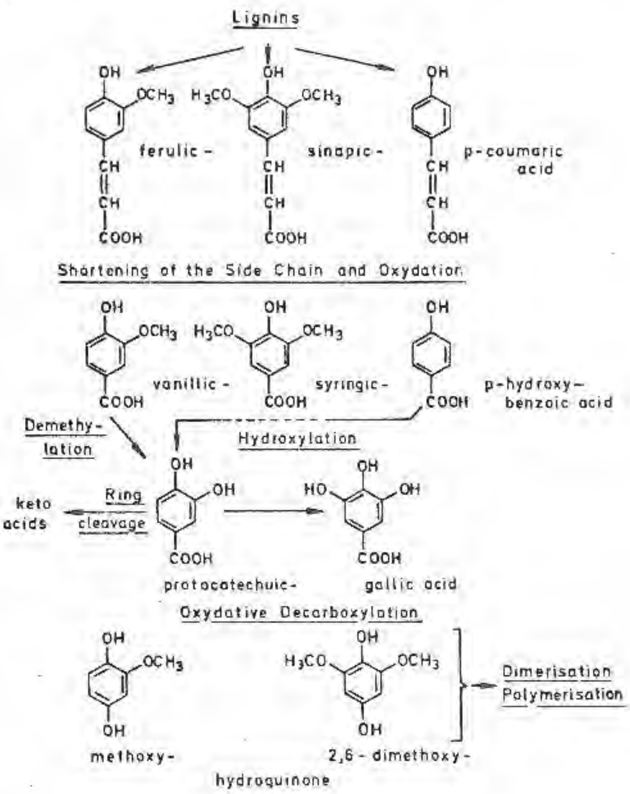


Fig. 10: Transformation of lignin degradation products.

In this figure the transformations of lignin degradation products are summarized. The side chains of cinnamic acid derivatives are shortened mostly by the cleavage of two carbon atoms to corresponding phenol carboxylic acids. The most important reactions are 1. hydrooxidation, 2.demethylation, 3. cleavage of the ring, 4. oxadative decarboxylation, and 5. polymerization reactions.

For the subject which has been taken up in this lecture especially the oxidative decarboxilation is effective because the formed decarboxilation products are 100 times more active in plant metabolism than phenol carboxilic acids.

It can be mentioned that methoxy substituted diphenols are also formed in the plant after uptake of corresponding acids.

Tab. 4: Influence of phenol carboxilic acids on plant mass production in sand cultures and Mitscherlich pots.

Concentration in Mol	p-Hydroxycinnamic Acid Sprout	p-Hydroxycinnamic Acid Root	Vanillic Acid Sprout	Vanillic Acid Root
0	100	100	100	100
10^{-4}	116	103	123	130
10^{-5}	118	103	117	126
10^{-6}	95	100	107	118

Influence of Protocatechuic Acid and Vanillin on the Relative Yield of Summer Wheat (Mitcherlich Pots)

Concentration in Mol	Protocatechuic Acid Grain	Protocatechuic Acid Straw	Vanillin Grain	Vanillin Straw
0	100	100	100	100
$6.\ 10^{-5}$	111	104	113	108
$12.\ 10^{-5}$	110	113	111	111

Underlined values statistically significant

Differently substituted phenol carboxylic acids were added in different concentrations to send or soil cultures. According to concentration substitution and environmental conditions, the dry weight of rye seedlings or the yield of grains and straw increased. The underlined values are statistically significant. To get the casual connections between the physiological effect of the substances and increase of yields in dependence of concentrations, it is necessary to study at first the uptake of these substances by plant roots, the transport and the transformation of these substances in the plants. For this purpose differently labelled phenol carboxylic acids are synthesized.

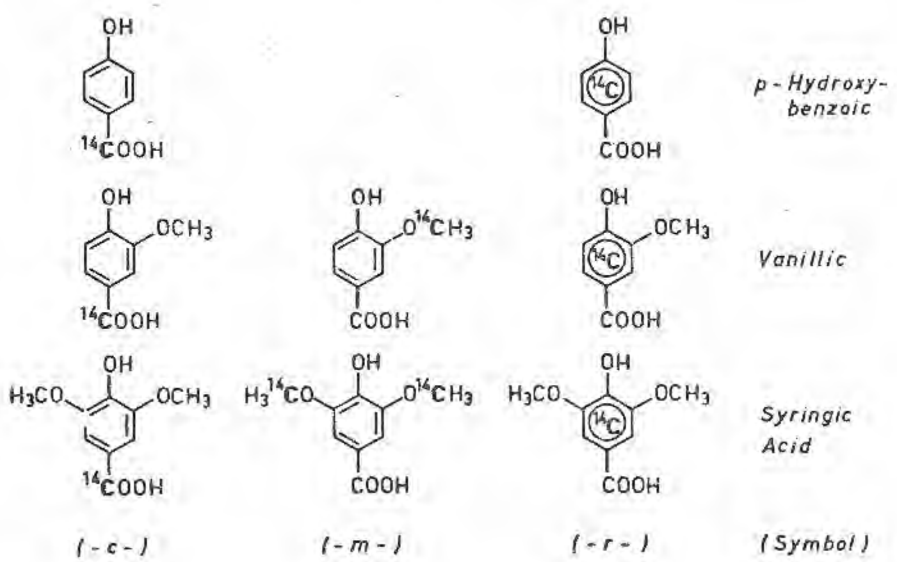


Fig. 11: Differently labelled phenol carboxylic acids.

Phenol carboxylic acids were labelled in the carboxyl group, in the carbon atom of methoxyl group or uniformly in the ring. By measuring the formed $^{14}CO_2$, the activity of extracts of special fractions and by radioautography transformations of the added acids, participation and metabolisms and some singularities of the transport can be established. The symbols used are - 'c' for carboxyl, 'm' for methoxyl and 'r' for ring labelling.

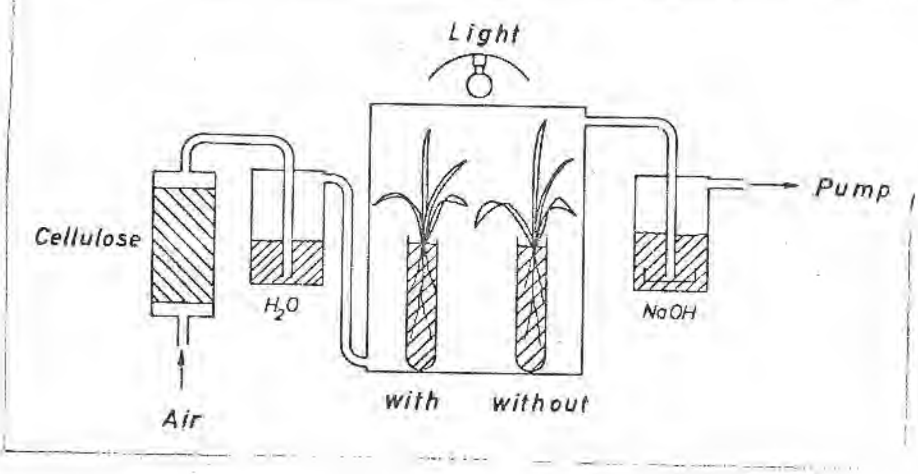


Fig. 12: Scheme of operatives to study the uptake of phenol carboxylic acids.

For studies about uptake of labelled phenol carboxylic acids, it is necessary to work in strictly sterile conditions and in a closed system. By the measure, it is prevented that the possible degradation products formed by microbial activity disturb the experiments. With an air stream the volatile products such as CO_2 are transported and absorbed in NaOH solution. Light intensity, temperature and humidity can be regulated.

To warrant sterility, every germinated seed is fixed under sterile condition with a glass folk in a single small vessel. Only one example of results will be mentioned as representative of many investigations.

The determination of activity only in the plant organs does not inform about the occurred processes. One must find out to which compounds the different amounts of activity belongs.

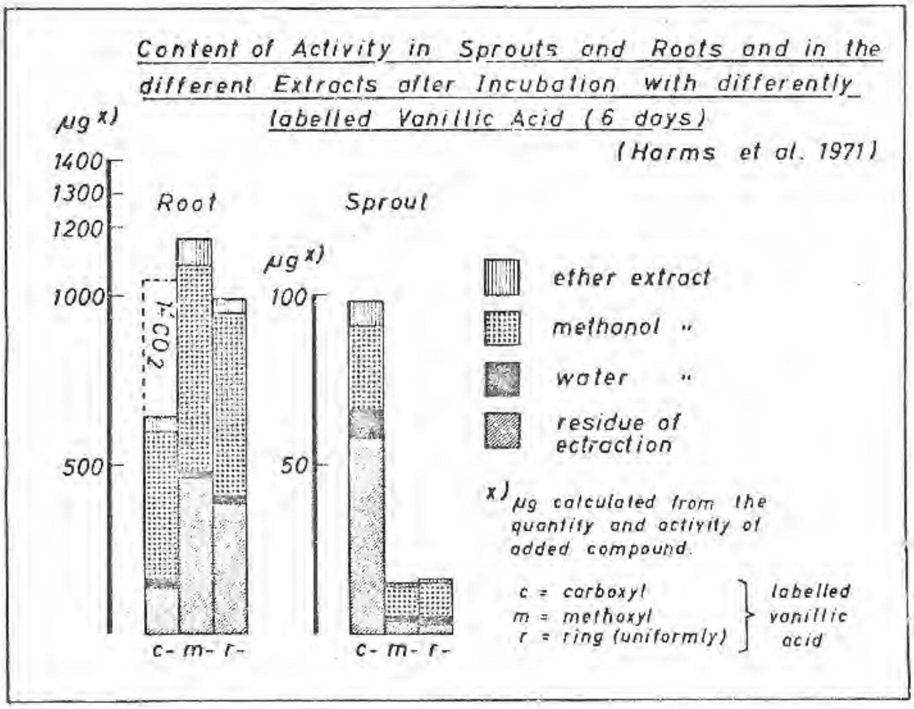


Fig. 13: Content of Activity in sprouts and roots and in the different extracts after incubation with differently labelled vanillic acid (6 days) (HARMS et al. 1971).

In the case of differently labelled vannillic acids the most important findings are concluded as follow:

1) The activity in roots is about 10 times higher than in the sprouts.

2) In the case of carboxylic labelled Vannillic acid the activity in the roots is lower than that in the case of methoxyl or ring labelled Vanillic acid. In the sprouts it is just opposite.

3) The amount of free vannilic acid is relatively less in all cases according to the activity in the other extract.

4) Relatively higher amount of activity in the methenol extract belong to glucosides or glucosesters and esters of glucosides of differently labelled vanillic acids.

5) In the case of carboxylic labelled Vannilic acid in the water extracts and in the residues of extract, are mainly labelled compounds which are formed by endogenous fixation of labelled CO_2, such as cellulose, lignin, proteins, amino acids etc.

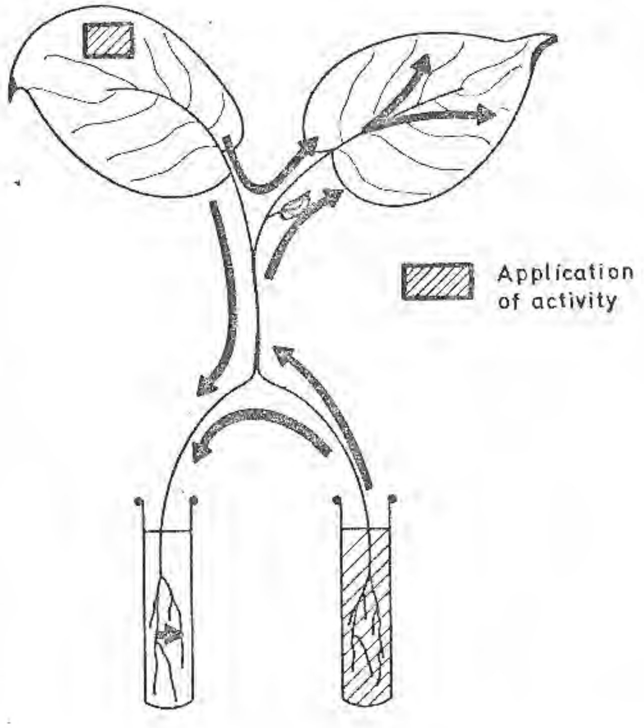


Fig. 14: Distribution of the activity in the plant.

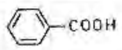
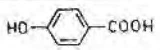
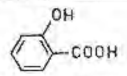
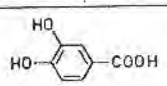
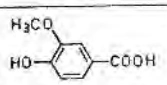
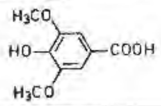
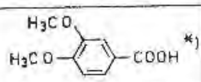
The transport of the added phenol carboxylic acid occurs in acropetalic-basipetalic-transpetalic direction, but only as free acids; glucosides are not transported.

These investigations are not only of academic interest but may become important for plant breeding work. In different other institutes it was established that the resistance against different fungi is increased with the increasing content of such type of plenolic acids in the plants, so for instance in the case of wheat, maize, potatoes and grapes. Some programmes with other institutions are under progress. These mentioned substances also increase the resistance against drought. In connection with the above mentioned project, we investigate the enzymes in the plant metabolism which are altered by differently substituted phenol carboxylic acids. For this purpose we work with sterile plant cell suspension cultures, i.e. moong bean, soyabean and wheat.

The shaking cultures are made under standard conditions, they have the advantage that the results are available in shorter times because one must not wait for the uptake of the substances by the roots and the rate of transformations of the added compounds is higher.

Tab. 5: Réleased 14 - Carbondioxide from Phenol Carboxylic acids in Cell Suspension Cultures of Soybean after 72 hours (Berlin et al. 1971).

Released 14-Carbondioxide from Phenol Carboxylic Acids in Cell Suspension Cultures of Soybean after 72 hours. (Berlin et al. 1971)

	$^{14}COOH$	$-^{14}CH_3$	
	0		0
	21,1		1,0
	1,4		-
	65,9		12,5
	83	1,5	0,4
	88	1,5	-
 *)	1%	64%	0,1%
 *)		3-O-Methyl 0,8% 4-O-Methyl 52%	

*) Other Experiment.

Some results of these investigations establish:

1. The preposition for decarboxylation is a hydroxy-group in p-position to the carboxyl group: 2. Remarkable demethylation occurs only when the methoxyl group is in the p-position to the carboxyl group. 3. The cleavage of the ring needs a hydroxyl group in 3-4 position.

Uptake, transport and transformation of the phenol carboxylic acids depends on the environmental conditions.

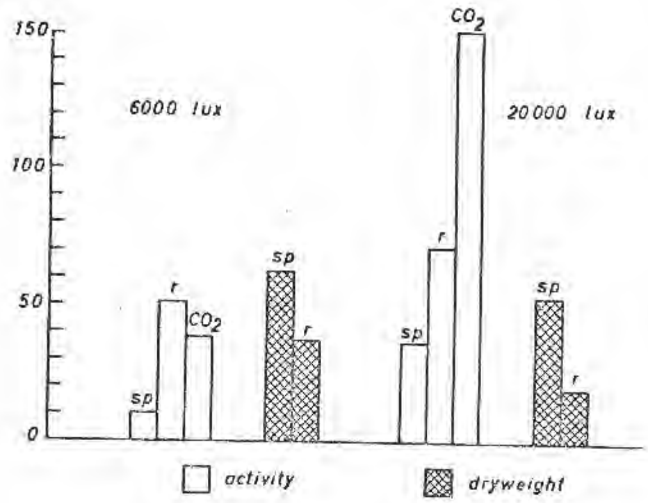


Fig. 15: Uptake of vanillic acid and formed 14-Carbondioxide in per cent of added acid and dry weight of sprouts and roots (relative numbers).

So for example high light intensity increases in the case of carboxylic labelled vanillic acid not only the activity in the sprouts and roots but also the amount of released labelled CO_2. The alterations of the dry weight, especially in the case of sprouts, are less than the differences in activity (Harms et al. 1969a).

This experiment is also a contribution to the uptake of phenol carboxylic acids as an active process (Kastori et al. 1970).

We use smaller climate chambers to examine the influence of environmental conditions on these processes. Temperature, humidity and the light intensity can be continuously regulated according to different programmes to similate a day under different climates. The light source is high pressure Xenon lamps.

This equipment is sufficient to study the differences in growth caused by changed environmental conditions. It is not so sensitive against disturbances and expensive in management as the other sophisticated phytotrons. In this way, it is possible to get much faster results for special questions.

For the time being, I will mention the present theory regarding the mode of action of physiologically active substances without going into details. Some of phenols and quinones respectively form complexes with alkali ions. By these complexes the charge and permeability of the cell membrane for the cations is changed and therefore also uncoupling of oxidative phosphorylation according to themi-osmotic theory of Mitchell (1966). We determined the effect of differently methyl substituted benzo-quinones on the production of the dry weight of wheat seedlings in sand culture with nutrient solutions. Otherwise we investigated the ability of these quinones to form alkali complexes.

$$Q^{-} + e^{\ominus} \longrightarrow Q^{2\ominus}$$

Q = quinone

Fig. 16: Reduction of semiquinone radical.

A measure for the ability to form complexes is the shift from the second polarographic wave of the quinones after addition of the ions. The wave corresponds to the reduction of the semiquinone radical.

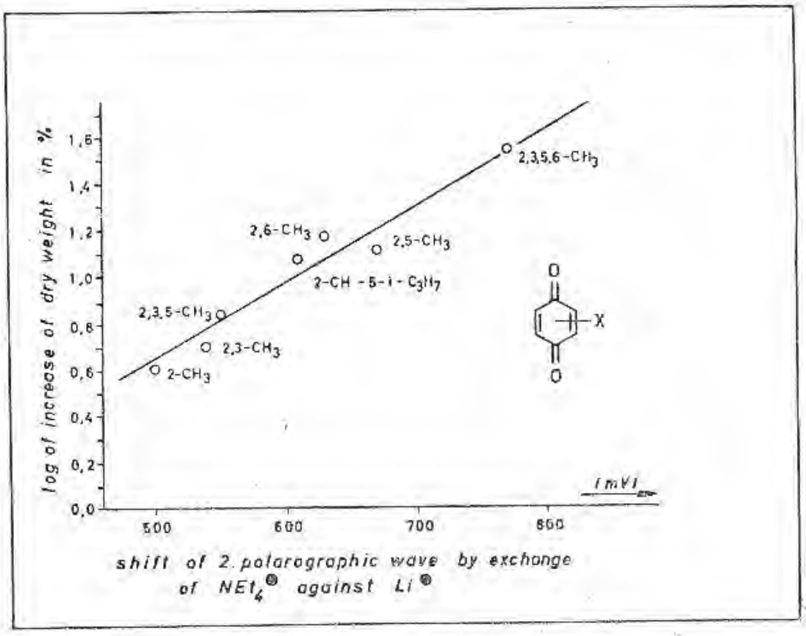


Fig. 17: Shift of second polarographic step by exchange of $NE^{\oplus}_4$ against $Li^{\oplus}$.

If one plots the logaritham of increase of dry weight in per cent caused by the differently substituted benzoquinones against the ability to form complexes, a linear correlation is observed (Flaig and Riembr 1971).

No body doubts that the soil organic matter is an important factor for productivity and therefore also for the obtainable yields. Some of the influences of soil organic matter have been mentioned in this lecture.

The farmers need advices, how to manage the problems of soil organic matter as a factor for yield stabilization.

Science must work out methods according to which the characterization of the humic systems could be done in relation to soil productivity. With basic knowledges it may perhaps be possible to direct some processes during formation and decomposition of soil organic matter. The basic knowledges to elucidate some of the effects and finally also the contributions for the characterization of the humic systems are therefore very important.

During formation of humic substances different reactions occur. Some of them occur with preference, as it was shown in one of the previous slides; transformation of cellulose occurs faster than the alterations of lignin for instance. Even when the environmental conditions differ, humic substances are formed from initial material which has principally the same composition. Therefore, in the case of humification substances are formed which are similar or dissimilar in their composition and properties, but do not differ in a chemical sense such as benzoic acid and acetic acid. For this reason characterization of humic systems by determination of chemical and physical data can only be made by means of statistical methods.

In a larger project the characterization of humic systems is done by standardization of methods and values and by comprehensing and evaluating with electronic equipments.

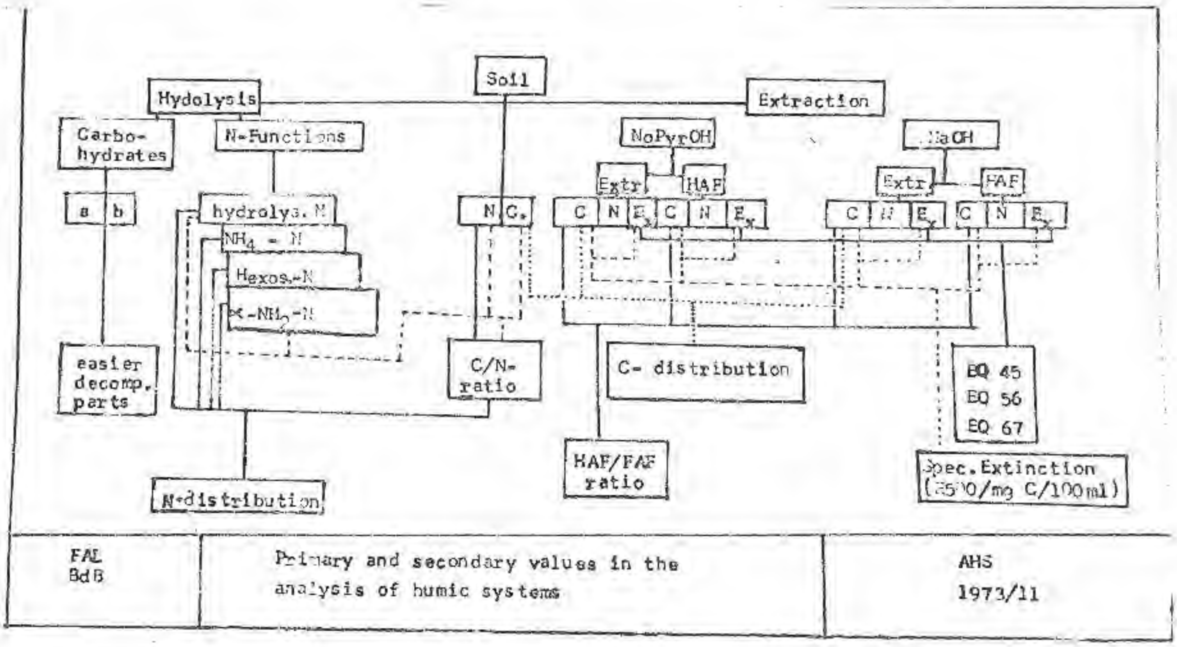


Fig. 18: Primary and secondary values in the analysis of humic systems.

Different values are determined with more or less automatic instruments and registered for computor. From these primary values the secondary values are obtained. All values are statistically treated. I cannot go here in details but the aim will be to find out correlations between some properties of humic substances, their alteration during vegetation and their contribution to the potential of the soil for plant production.

The light absorption at ten different pre-determined wave length can be measured using automatic spectrophotometer, where the values are registered by a typewriter on a list together with the sample number or registered on band punch cards.

One measurement needs approximately 1½ minutes. Operatives can work in day and night times. The optical density of colours for determination of reference reactions can be measured in these operatives automatically. The dosages of reaction solutions, reaction temperature and time are also automatically carried out. The values are registered for evaluation as before. It is continued development of the system. Autoanalyzer of Technicon can be more universally used also.

As the transfer of basic knowledge in the field of practices is the production of slow releasing nitrogen fertilizer by oxidative ammonization of lignin containing waste liquor of pulp and paper industries.

Supply of plants with the nitrogen as the functions of metabolism demand during the vegetation period would be ideal for their nutrition and consequently for their yield. This ideal nitrogen source for plants nutrition is not reliable, but one should try to approach to it by technical means. Oxidatively ammonized lignin from waste liquors contains between 18-20% of total nitrogen from which one-third is ammonium nitrogen and two-third of nitrogen is differently organic bound. About the suitability of this slow releasing nitrogen fertilizer which we call N-Lignin, has been reported in lectures 3 and 4. I will report only about its main properties with some schemes.

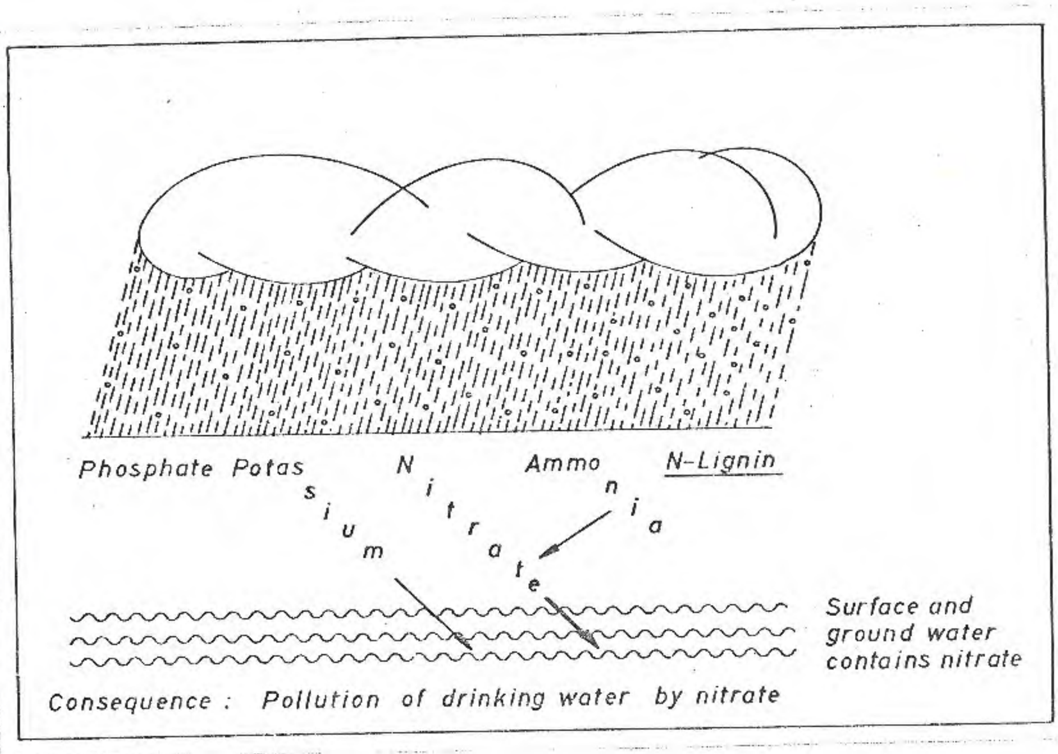


Fig. 19: Less leaching of N-Lignin in comparison to mineral fertilizer.

Some further properties are:

1. The slow release of nitrogen during vegetation period dependent on environemental conditions.
2. Inhibition of nitrification.
3. An effect of increased phosphate uptake and some others. At the moment Pilot plant is running at a capacity of 500 tonnes per year.

The pilot plant is built up in Chemische Fabrik Kalk in Köln by cooperation with Lurgi, Frankfurt.

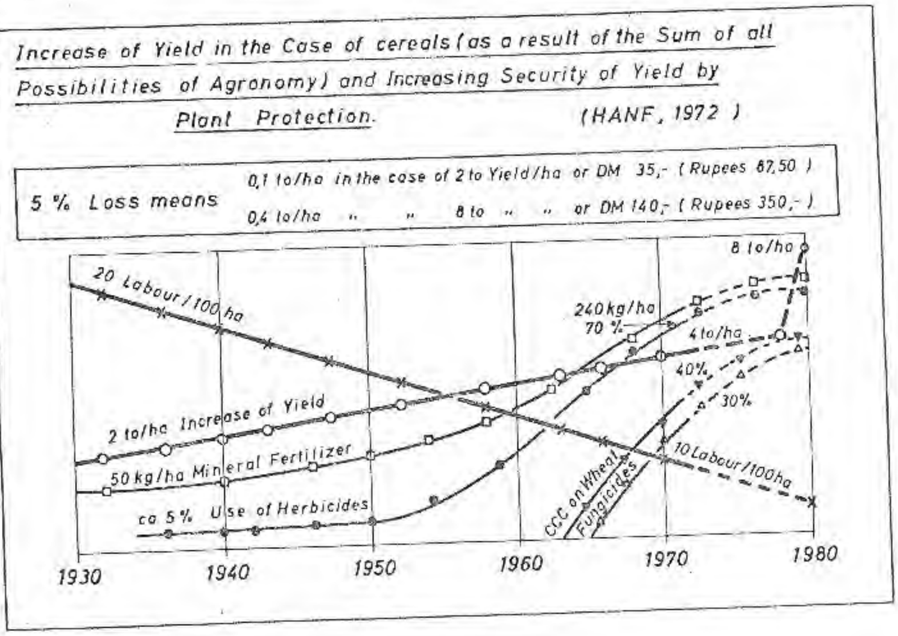


Fig. 20 : Increase of yield in the case of cereals (as a result of a sum of all possibilities of economy) and increasing security of yield by plant protection.

The possible economic measures and roles played by physiologically active substances for increase in yield and its stabilization are shown in an example from Germany in the year 1971. In Germany the average yield of cereal increased from 1930 to 1970 from 2 tonnes per hectare to 4 tonnes/ha. In very good agricultural farms is today 60 tonnes/ha or more. For the future 80 tonnes/ha are endeavoured and are certainly attainable.

At the same time the number of labourers decreased from 20/100 ha to 10/100ha due to mechanisation. In our country the number of labourers per 100 ha will decrease further.

The first phase of increase of yields about 20 years ago was the increased mineral fertilization, the breeding and the improved soil management. Most important factor for yield increase is mainly mineral fertilization from about 50 kg/ha total nutrients in 1930 to about 240 kg/ha total nutrient in the year 1970.

The increased doses of fertilizers require a more intensive weed control measures. This can be done only with labour saving chemical means by the use of physiologically active substances.

Because at first used chemical had a stronger effect against dicotyledones than against mono-cotyledones, new effective substances have to be found which are also effective against grasses as weeds. Nitrogen fertilization alone does not allow to use the total genetical potential of cereals. Therefore, an increase of yield only by nitrogen fertilization is limited. In the case of too high nitrogen fertilization, lodging of cereals occurs mostly. The development and use of means to increase the resistance against lodging such as cycocel (CCC), dichlorocholine chloride have overwhelmed this biological border and allowed to use better the total genetical potential of the modern high yilding varieties.

An intensive cereal production is only then economical when continuously yields with the same levels are obtained. For this an increased protection against yield diminishing factors is necessary. A diminition of loss of yield by 5% means 1 quintal at a level of 2 tonnes/ha or at least 35 DM/ha in the case of foreseen yield of 8 tonnes/ha, however, 140 DM. The higher the possible yields, the more additional measures are payable and have to be paid.

The use of bioregulators promises new possibilities for the diminition in yield variations. (See Fig.18 Lecture 1).

Also in the next decade the soil will be the most important base for plant production. The second phase to increase yield by mineral fertilization, breeding, soil management and plant protection is in principle almost settled, even some improvements are still possible. The next step must be that the yield depressions are minimized as much as possible by the use of bioregulators. One of these for instance is the mentioned cycocel to diminish lodging in the case of wheat under abnormal environmental conditions. To elucidate some further possibilities such as nitrogen nutrition of plants still unknown adopted to its needs, increase of resistance against draught and others by bioregulating substances will be one of the most important task for the future research about the biochemistry of soil organic matter or with other words in the system soil and plants. The possibilities to stabilize the yield is very important economical factor for the farmers and also for nutrition of world population.

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