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

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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

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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

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AND ITS SPECIAL EFFECTS

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1 Results of a pot experiment conducted for 11 years

From the former experiments, it can be established that the utilization of Nitrogen in N-Lignin is somewhat lower than in case of mineral fertilisers. Therefore, larger amounts of nitrogen from N-lignin must have not been mineralised or were fixed due to processes in soil. To solve this problem a pot experiment was conducted for 11 years. The fertilizer was always same, but the plants differed from year to year. So it was possible to demonstrate accumulation processes. The treatments for fertilization are shown in the next table.

1.1 Plan of experiment

Table 1 : Plant of Pot Experiments conducted during 11 years.

Soil of experiment: Mixture from 3,5 kg Pseudogley-Chernozem (Asel near Hildesheim) and 3,5 kg Sand (Ø 3 mm)-air dried

Variants of experiment: (7 pots per variant)

Ratio g N from NH_4NO_3 to g N from N-Lignin

Dosis of fertilizer in g/pot			100: 0	75:25	50:50	25:75	0:100
N	P_2O_5	$K_2O^{+)}$	Variant Nr.				
0	0,8	1,2	1	-	-	-	-
0,5	"	"	2	-	-	-	-
0,75	"	"	3	-	4	-	5
1,0	"	"	6	7	8	9	10
1,25	"	"	11	-	12	-	13
1,5	"	"	14	-	-	-	15
2,0	"	"	16	-	-	-	17
0,75	0,6	0,9	18	-	19	-	20
1,25	1,0	1,5	21	-	22	-	23

+) N as $(NH_4NO_3$ P as $CaHPO_4\ 2H_2O$ and K as K_2SO_4

The soil was a mixture of pseudogley-chernozem and coarse sand in a ratio of 1:1. Treatments were replicated seven times. Besides a control without fertilisation a row of increased nitrogen addition from 0.5 upto 2.0 g N in the form of Ammonium Nitrate and of 0.75 up to 2.0 g N in the form of N-lignin per pot was made. The fertilization with phosphate and potassium was constant in this experiment. Different mixtures of N-lignin with Ammonium Nitrate have been included.

The P and K doses has been adjusted to the ratio of 1:0.8:1.2 in further experiments with 0.75 and 1.25 g N per pot.

The fertilization with P was made with Dicalciumphosphate and with Potassiumsulphate.

1.2 Yield of Grain

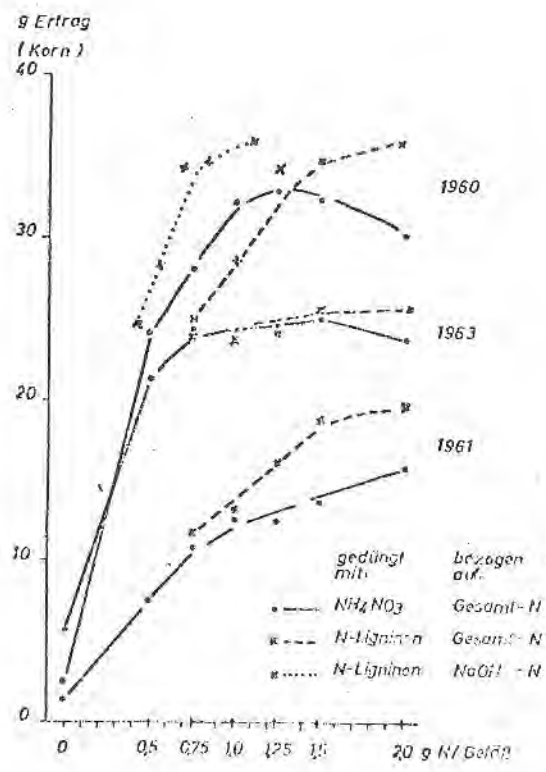

Fig. 1: Yield of grain in the year 1960, 1961 and 1963 (Söchtig 1972).

The yields of grain are plotted in gram per pot against the dose of N per pot for the first 3 years. The curves of yield by fertilization with Ammonium Nitrate correspond always to one which has been shown in the figure before. The curve of yield with N-lignin is for the first year at lower doses of nitrogen under that of mineral fertilization. The curve crosses this with mineral fertilizer at 1.25 gram N per pot and is afterwards remarkably above the yield with Ammonium Nitrate. If one calculates not with the total N content of N-lignin but only with this part of N which can be distilled with Sodium hydroxide, the curve of yield with N-lignin for the year 1960 is above the curve of mineral fertilization at all doses. By this fact, it may be concluded that more nitrogen is releazed by N-lignin than it can be determined by distillation with Sodium hydroxide. If one calculates release of nitrogen from both types of fertilizers, then the uptake from N-lignin is 75 per cent of this from Ammonium Nitrate in pot experiments under the environmental conditions of middle Europe.

For the year 1961, the curve of yield for N-lignin is always higher than this for Ammonium Nitrate at all doses of fertilisation. In this year, there had been heavy rainfalls in April and May, so that the soils in the pot have been water leached.

During a longer time a flow of water occurred. It was a determined that in average 40% less nitrogen was released from the pots fertilized with N-lignin for comparison with pots fertilised with Ammonium Nitrate. The water flow was added to the pots at drier season so that the differences of yield can not be explained by shortage of nitrogen, but with its other distribution. Otherwise it may be rememberd that in water leached soil low molecular weight organic compounds have an effect on the formation of yield, as it was mentioned in the introductory lecture.

In the year 1962, spinach was planted which is not mentioned in the figure. In 1963, Summer Wheat was planted as in the year 1960. The effect of lower doses of N-lignin fertilisation was equal with that of Ammonium Nitrate. The yield from N-lignin at higher doses was higher than that of Ammonium Nitrate. A cumulative effect of N-lignin is therefore clearly represented at lower doses of fertilizers after 4 years. The positive effect of higher dose of N-lignin remains.

1.3 Utilization of nitrogen.

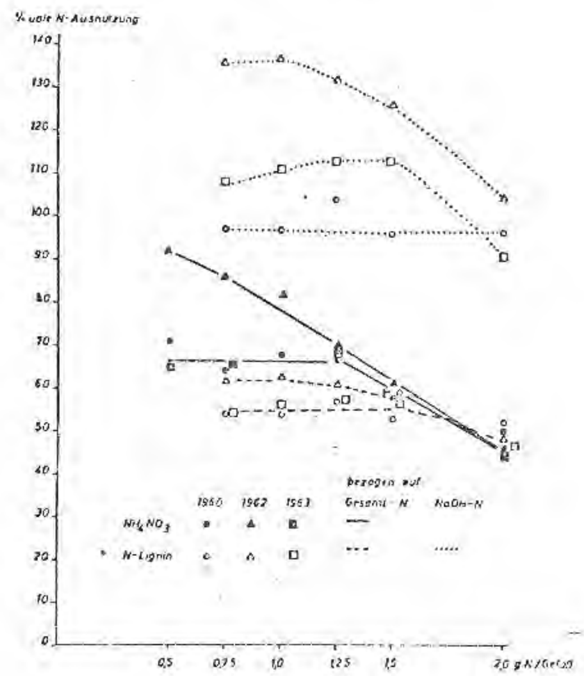

Fig. 2: Percentage of utilization of nitrogen for the year 1960, 1961 and 1963 (Sochtig 1972).

The uptake of nitrogen in the first years of experiment are shown in the above figure. The uptake of nitrogen from N-lignin showed the differences mentioned previously. The curve of percentage nitrogen utilization calculated from total nitrogen content of N-lignin are lower than that of ammonium nitrate, but are above when calculated on the basis of nitrogen distillable with sodium hydroxide.

Many experiments with N-Lignin demonstrate that nearly same high yields could be produced by lower uptake of nitrogen as it is the case with Ammonium nitrate.

This means that the amount of nitrogen from N-lignin was better used for yield formation than from Ammonium-nitrate. The causes for this may be better distribution of N-uptake and the effect of physiologically active substances which have already been mentioned.

1.4 Accumulation of carbon and nitrogen in soil

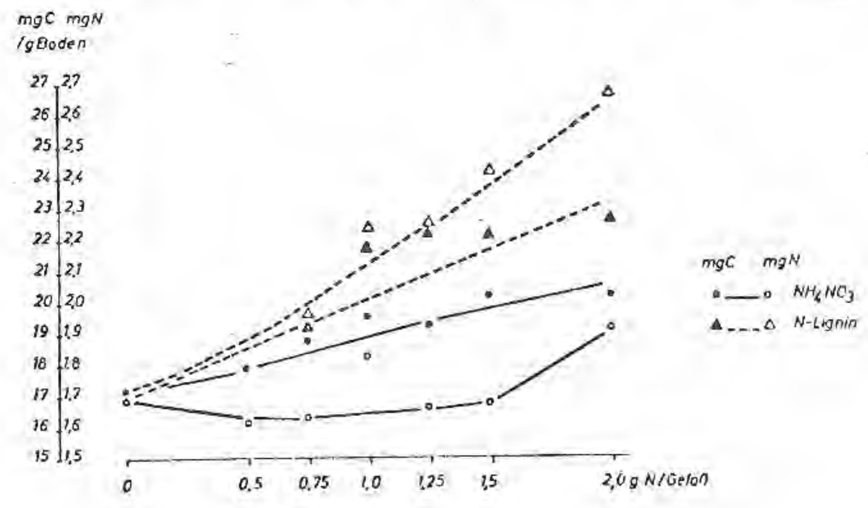

Fig.3: C and N content of soil in pot experiments after 10 years (Sochtig 1972).

If one compares the C and N content in the different fertilized soils after 10 years, it can be demonstrated that Carbon content in the soils fertilized with Ammonium Nitrate increases little. This may be due to the increase in production of roots, but the nitrogen content of the soil is changed little and increases only at the highest dose of Ammonium Nitrate.

In contrast to this the Carbon content was increased by fertilisation with N-lignin. Nitrogen content increases remarkably from about 1.7 mg. to about 2.7 mg per gram soil. In the soils fertilized with N-lignin an enrichment of nitrogenous compounds is favoured up to 60%.

As an effect of this enrichment can be observed also that the amount of available nitrogen after winter time is increased in the pots fertilized with N-lignin. This concerns the content of Ammonium as well as that of Nitrate ions.

At the moment we make some physical experiments with soils treated with N-lignin. Water-holding-capacity seems to be increased and the compressibility by heavy vehicles decreased, as it can be concluded by preliminary results.

2. Uptake of nitrogen from N-lignin during one vegetation period.

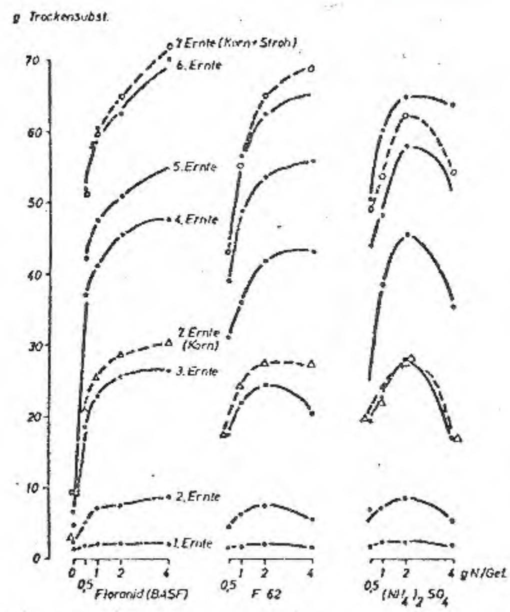

Fig. 4: Yield of dry weight of different stages of growth of summer wheat (pot experiments). (Sochtig 1972).

To study the development of plants during vegetation period in dependence of different types of fertilizers (Fig.4) and the uptake of nitrogen in dependence of time (Figure 5), plants were harvested at different stages of growth.

In this way, the formation of yield was followed for increased fertilization with Floranid (BASF), a dondensation product from Crotonaldehyde and Urea (1:2), a product of N-lignin and Ammoniumsulphate. First harvest was made after 4 weeks, next harvests always at an interval of 14 days. First harvest showed no differences. After the second harvest, showed the depressions of the yield can be observed in the case of N-lignin as well as in the case of Ammoniumsulphate at higher dose of nitrogen. The depressions of the yield remain in the case of Ammoniumsulphate upto the harvest of grain while this does not occur more in case of N-lignin after 3rd harvest.

Different reasons may exist for this retarding effect of higher doses at the first 3 harvests.

In the case of last harvests (No. 6-7), floranid gives a higher increase of yield than N-lignin. This must be due to less release of nitrogen from N-lignin, but the yield of grain shows no larger differences upto a dose of 2 g N/pot. In the case of 4 g N per pot Floranid is superior to N-lignin, while Ammonium-sulphate decreases the yield remarkably at this high dose. In spite of this effect of Floranid, it can not be recommended for cereal production, because one kg nitrogen of Floranid is about 3 times more expensive than the same from N-lignin.

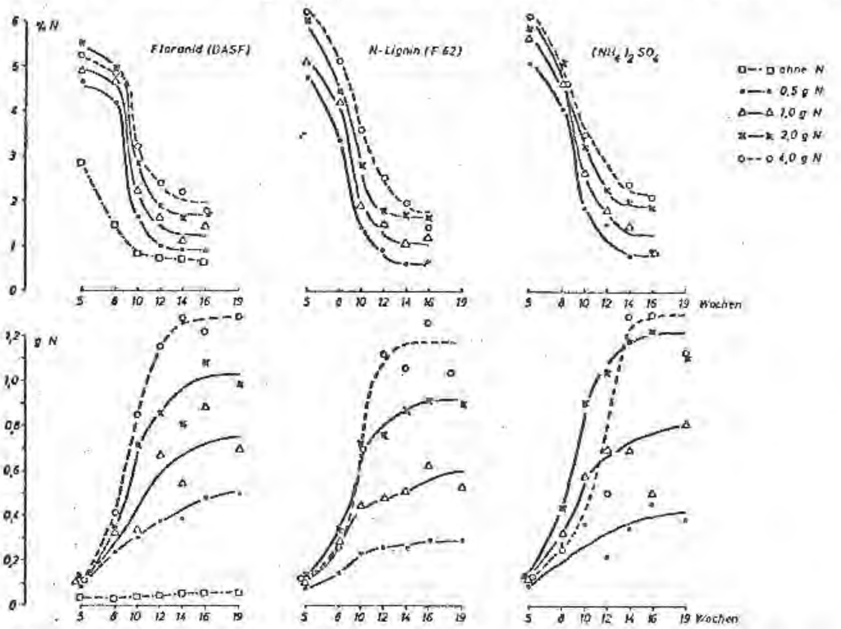

Fig. 5: Nitrogen content in per cent and in gram at different stages of development of summer wheat (pot experiment) (Söchtig, 1972).

If one plots nitrogen content in per cent against time for the different doses of nitrogen, curves like letter"S"occurred in all cases. Nitrogen content in the plants are higher at the first harvest in the case of N-lignin and Ammoniumsulphate than in the case of Floranid. At later harvest release of nitrogen from Floranid is little larger than that from N-lignin. The same effect is also observed, when content of nitrogen is given in gram. Thereby, depression at the beginning of growth in the case of Ammoniumsulphate by a higher dose of nitrogen is remarkable. Content of nitrogen and therefore the uptake of nitrogen from N-lignin is less, but the yield formation is nearly the same. A further influence of N-lignin on yield formation must exist besides the sole effect of nitrogen. One part of these influences are mentioned later.

Investigation about the content of free amino acids and in the protein hydrolysates have shown that quality of protein in the grain measured by the EAS index according to Oser, is the same inspite of the lower nitrogen content by fertilization with N-lignin. A difference in the free amino-acids exists mainly in the content of amides and in aspartic and glumatic acid, which means an influence on amino-acid metabolism. At present, we are investigating the influence of components of N-Lignin on the amino acid metabolism in plant cell suspension cultures.

These alterations of amino acid metabolism has some practical consequences.

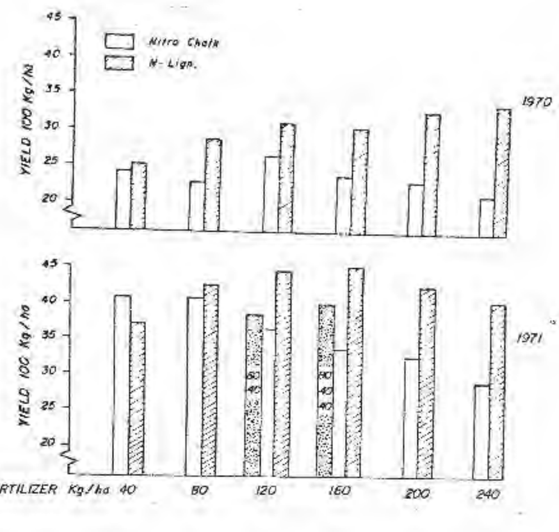

Fig. 6: Yield of grain of summer barley - dependent on quantity form and time of application of N-fertilizers (Dambroth, 1972).

The lower content of nitrogen in the grain of barley but without a loss of protein quality increases its commercial value from barley for foodstuff to barley for brewing.

According to the different climatic conditions in the year 1970 and 1971 the effect of N-lignin (shaded bars) differs but the yield is always higher than with Nitro-chalk. The barley produced with N-lignin had the quality for brewing. This produced with nitro chalk only in the year 1971 using N-lignin the former can be sure to harvest always barley with brewing quality.

3. Mineralisation and Nitrification of N-lignin.

It has been observed by experiments about transformation of nitrogen from N-lignin in a form which is available for plants that nitrification of ammonium ions which are in N-lignin and also those which are available by mineralisation, are much less transformed to nitrate as it is the case of ammonium ion in form of inorganic or organic salts. The effect of inhibition of nitrification has been investigated in several experiments to study the following consequences:

1) The plants take up both types of nitrogen; but from nitrate different metabolic pathways are necessary to transform it in aminoacids.

2) The mode of uptake for cations is influenced by the cation ammonium in other way than by the anion nitrate; therefore very different enrichments of diminitions of ions- especially nitrate - occur..

3) Ammonium ions are less transported in soil than nitrate ions.

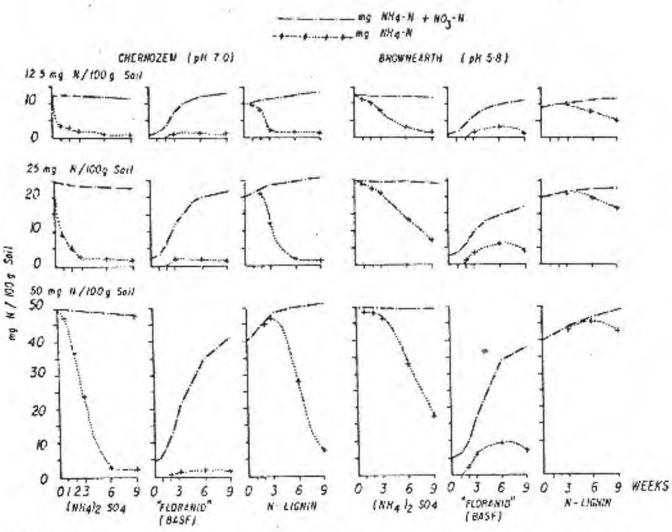

Fig. 7: Nitrification of ammonium sulphate, Floranid (BASF) and N-lignin in chernozem and brown earth (Söchtig 1970).

3.1 Comparison with other nitrogen fertilizer

Mineralization and nitrification of ammonium sulphate, Floranid (BASF) and N-lignin have been investigated in increasing amount in chernozem with pH value of 7.0 and brown earth with pH value of 5.8. Soils have been moistened to 60% of water holding capacity and incubated for longer time at 18°C and 90% relative humidity.

To both soils 12.5, 25 and 50 mg N/100 g soil have been added. The addition of N-lignin was calculated on the nitrogen content which is distillable with sodiumhydroxide.

From this experiment samples have been taken after different times (1,2,3,6 and 9 weeks), have been extracted with 0.1 N sulphuric acid saturated with potasium sulphate. Ammonium and nitrate ions have been determined according to Bremner (1965) by destillation method and total nitrogen content according to the Kjeldehl procedure.

Ammonium sulphate is very fast nitrified even in high doses as it is shown by the dotted lines. After 3 weeks 50 per cent is nitrified and after 6 weeks complete nitrification occurred.

Floranid is mineralised fast under this condition after 9 weeks to more than 30 per cent. An inhibition of nitrification cannot be observed.

In the case of N-lignin a remarkable inhibition of nitrification occurs with increasing doses. Even in the highest dose nitrification is not complete after 3 weeks. After 6 weeks, nearly only the half of the ammonium ion is nitrified and after 9 weeks about 20 per cent of the available nitrogen is found as ammonium ions. The difference between nitrogen distillable with magnesium oxide - this gives initial value on the first day of the experiment- and nitrogen distillable with sodium oxide is nearly complete mineralized in the times of three weeks. Afterwards, a slow increase occurs with time and is not finished after 9 weeks.

In the acid brown earth stronger decrease of the rate of nitrification occurs after an addition of ammonium sulphate; it is known that rate of nitrification is lowered by larger amount of ammonium ions. Floranid is mineralised more slowly and a less enrichment of ammonium ion occurs in this soil. The inhibition in the case of N-lignin is very strong in this soil. The inhibition is even still complete after 6 weeks by the highest dose and is approximately 90 per cent after 9 weeks.

3.2. Dependence on soil temperature.

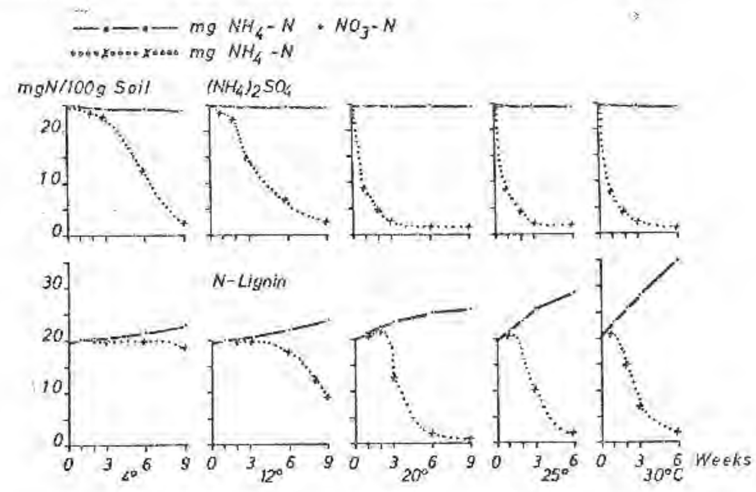

Fig. 8: Nitrification and mineralisation of ammonium sulphate and N-lignin due to soil temperature (SÖCHTIG, 1970).

Nitrification and mineralisation occur in the soil due to the activity of micro-organism; this is much influenced by temperature.

With increasing soil temperature, nitrification of ammonium sulphate in chernozem is increased, whereby nearly no alteration of nitrification rate occurs when temperature is higher than 20°C. The nitrification of N-lignin is also dependent on temperature; its nitrification is increased with increasing temperature.

In all cases N-lignin inhibits nitrification in contrast to ammonium sulphate. The mineralisation of N-lignin is more influenced than the nitrification. This can be concluded from the curves of the sum of the nitrate and ammonium nitrogen. Only a small mineralisation occurs at 12°C, but it increases much with increasing soil temperature

It can be concluded that the availability of Nitrogen from N-Lignin increases in soil which are warmer than middle Europe. It must be established that in warmer soil much more nitrogen from N-lignin is available for the plants than it corresponds to the value obtained by distillation with sodium hydroxide.

The dependance of the rate of nitrification on soil temperature shows also the limit of the utilization of this inhibition of nitrification for distinct use of N-Lignin, for instance, for the production of vegetables which are poor in nitrate as will be shown later in details.

3.3 Inhibition of nitrification by components of N-Lignin.

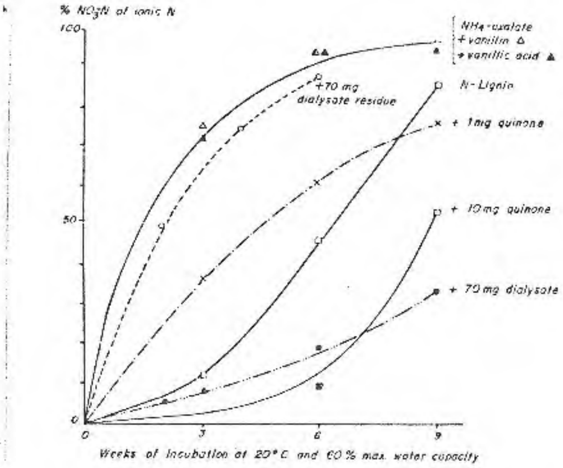

Fig. 9: Inhibition of nitrification by compounds which can be presented in N-Lignin.

We have been interested to elucidate the type of compounds in N-Lignin which may effect the inhibition of nitrification. The experiments have been made with different ammonium salts. For instance, in case of ammonium oxalate, nitrification of the ammonium ion to nitrate is 70 per cent after three weeks. After 6 weeks more than 90 per cent. After 9 weeks more than 95 per cent ammonium is nitrified.

As components of N-lignin which could inhibit nitrification, we investigated different lignin degradation products vanillin, vanillic-, p-hydroxy-benzoic acid and others have been added, but these compounds do not influence the nitrification rate.

The residues of dialysis in a concentration of about 14 mg of total nitrogen/100 g nitrogen from ammonium oxlate effects a small inhibition. But the same amount of dialysate lowers nitrification after three weeks about 90 per cent, after 6 weeks about 80 per cent after 9 weeks about 30 per cent. This shows that nitrate nitrogen is 10 per cent, 20% and 70% of the total nitrogen.

Because during oxidative ammonisation of the lignin waste liquors also phenolic degradation products may be formed, we included some phenols or quinones in this investigation. If one uses a model substance like thymohydroquinone in an amount of 1 mg the nitrification is more inhibited than by the residues of dialysis. By an addition of 10 mg, a remarkable effect on inhibition of nitrification can be observed.

By this experiment, it can be concluded that simple lignin degradation products do not effect the inhibition of nitrification, but only stronger oxidised degradation products. According to further experiments, it might be possible that the inhibition of nitrification is also caused by low molecular weight hetrocyclic compounds.

3.4 Nitrification of mixtures of Ammonium salts and N-Lignin.

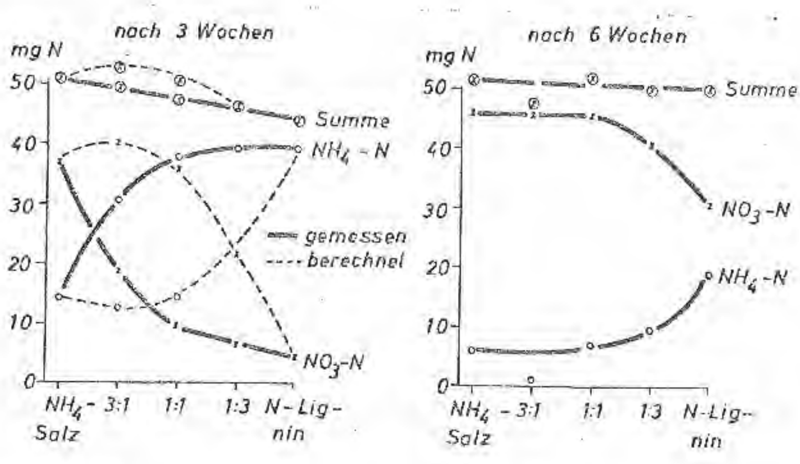

Fig. 10: Nitrification of mixtures of Ammonium salts and N-Lignin (Söchtig, 1970).

Above, the influence of N-lignin on plant yield was mentioned. It could be shown that mixtures of N-lignin and Ammonium salts had an effect on yield increase. Therefore, all such mixtures have been investigated for nitrification, because the nitrification of these mixtures is remarkably influenced by their N-Lignin content.

On the left side of the Fig. the full lines connect the determined values, the dotted lines- the calculated values of the different ions as well as their sum when Ammonium salts have been nitrified without an addition of N-lignin.

After three weeks, inhibition occurs in a mixture of three parts of Ammonium salts to one part of N-Lignin to remarkable extent. The mixture 1:1 has nearly the same effect on inhibition of nitrification as N-Lignin alone. After six weeks of incubation time only an inhibition of nitrification is observed when the mixture consists, at least, of one part of ammonium salts to three parts of N-Lignin or N-Lignin alone.

4. Influence of inhibition of nitrification on content of nitrate, phosphate and potassium in the plants.

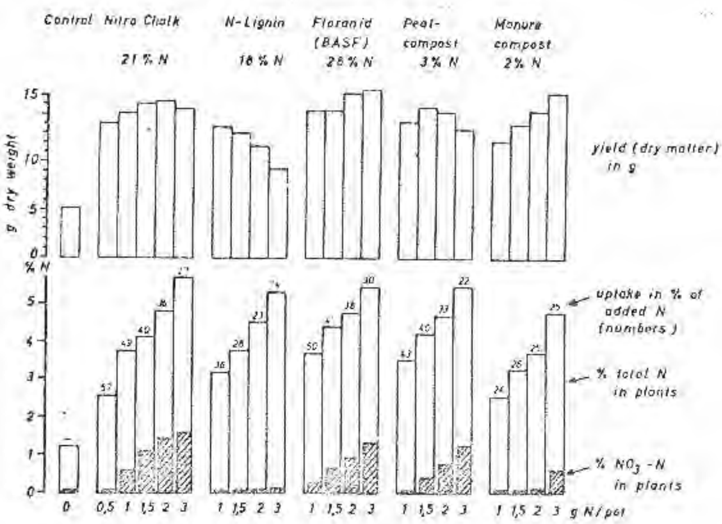

Fig. 11: Yield of spinach and its nitrogen content in a chernozem soil: experiment in spring time 1967 (Söchtig,1967)

The inhibition of nitrification by N-Lignin should effect a diminition of nitrate content in fast growing vegetables. High nitrate content in spinach may lead to reduction of nitrate to nitrite during wrong processing of spinach for food. Nitrite may cause a reduction of hemoglobin - red colour matter of blood - to methemoglobin. In the case of babies and patient of gut the illness of Methemoglobinemy may be caused.

Experiments have been made with spinach and additionof increasing amount of nitro-chalk, N-Lignin, Floranid (BASF), peat compost and manure compost. From the upper part of the figure it can be seen, that the yield in the case of N-Lignin is not so high as in the case of the other fertilizers. But the nitrate content of the harvested spinach is much lower than in the other cases and vegetable can be sold with a higher price for production of special food.

In the case of manure compost which was from the production of mushroom, the inhibition of nitrification is due to an addition of pesticides to this compost.

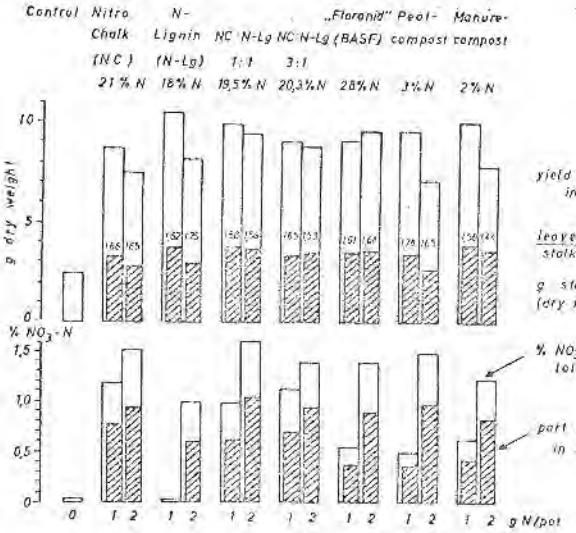

Fig. 12: Yield of spinach and its nitrogen content in a brown earch; experiment in autumn 1966, (Sochtig, 1967).

Another experiment has been made on brown earth in autumn. This time the temperature of the soil was remarkably higher. Therefore, by this changed condition the diminition of nitrogen content in was not so much. In this connection, it may be remembered that inhibition of nitrification decreases by higher temperature.

The yields of spinach are depicted in upper part of Fig. 12. Under these conditions, the yield of spinach is found higher than in the case of all other fertilisers.

It can be seen from the same figure that the nitrate content is lower in the case of N-Lignin, but not so much as in the case of experiment in spring time. The amount of nitrate nitrogen is much higher in the stalks than in the leaves.

Table 2: Experiments with spinach 1966 and 1967; content of total N NO_3-N P_2O_5 and K_2O (SÖCHTIG, 1967).

g/N	in form of	fresh weight in g	% Dry matter	$\%NO_3$-N	% N	$\%P_2O_5$	$\%K_2O$
				in dry matter			
1. Experiment +)							
0	-	38,2	13,1	0,06	1,27	1,12	3,7
0,5	NC	137,3	10,3	00,06	2,61	0.02	9,7
1,0		176,2	8,6	0,61	3,82	0,98	11,4
2,0		196,2	8,4	1,30	4,88	1,14	11,6
1,0	N-Lignin	142,1	9,6	0,06	3,27	1,13	9,2
2,0		127,6	9,3	0,08	4,60	1,18	8,9
2. Experiment ++)							
0	-	24,8	13,6	0,06	1,38	0,99	2,9
1,0	NC	98,5	8,9	0,59	4,47	0,91	8,6
2,0		107,1	8,7	1,01	4,96	1,03	8,7
1,0	N-Lignin	115,9	8,8	0,38	5,30	0,94	8,0
2,0		126,8	8,6	0,75	5,58	1,25	8,5

+) Experiment, beginning: 23.4.1966, plantet: 25.4.1966 harvested: 6.6.1966

++) " " 2.4.1967, plantet: 10.5.1967 harvested: 13.6.1967

NC = Nitrochalk

In this figure a detailed experiment on the influence of inhibition of nitrification on uptake of nitrate, total nitrogen phosphate and potassium is depicted.

Summarising, it can be said, that in all cases where the nitrate content in spinach is low, ammonium ions are favourably uptaken. Phosphate content is increased. Potassium content is remarkably decreased. These differences werealso observed not only in the case of nitrophylic vegetable plants but also in the case of grasses for instance German rye grass.

The differences in phosphate and potassium content are explained more or less with alteration of equilibrium of uptake of cation and anions by the plants.

But some findings make us believe that the cation-anion equilibrium is not solely responsible for the increase of uptake of phosphate in the presence of N-Lignin.

It is known since a longer time, that soil organic matter as well as organic fertilization increases availability of phosphate by diminition of fixation of phosphate in form of iron-alluminium- or calcium - phosphate respectively. This occurs also in the case of N-Lignin as experiments have shown on soils which are poor in phosphate or are fixing phosphate. The effect of increasing availability of phosphate by N-Lignin can be also clearly demonstrated in test experiments with laterite red loams.

Further experiments have been made in concrete boxes with a soil in bad structure.

Table 3: Results of an experiment with spinach in concret boxes, at different fertilization; degraded Loess loam, pH 6,4; coated and crusted (Chemische Fabrik Kalk-Koln)

Fertilization kg N/ha		Yield to/ha	% NO_3 in Dry Matter
80	N-Lignin	4,1	0,26
80	$(NH_4)_2SO_4$	2,4	1,45
80	Nitrochalk	3,0	1,93
160	N-Lignin	4,8	0,40
160	$(NH_4)_2SO_4$	2,7	1,95
160	Nitrochalk	3,3	2,62

Results as mentioned earlier were found in concrete boxes and in the field with spinach. A distinct diminition of nitrate content was found on degraded Loess loam by comparison of the effect of N-Lignin with Ammonium sulphate and nitro-chalk.

Table 4: Influence of N-Lignin on the content oxalic acid in spinach

Fertilization: 120 kg N/ha

	% Oxalic acid in dryweight	
	Spring	Fall
NPK without N-Lignin	11,0	9,0
NPK with 50% N-Lignin	9,3	7,9
NPK with 100% N-Lignin	5,8	4,6

66666

Not only nitrate content but also that of oxalic acid is diminished in spinach by fertilization with N-Lignin.

5 Diminition of leaching of nitrogen

1 Pot experiments

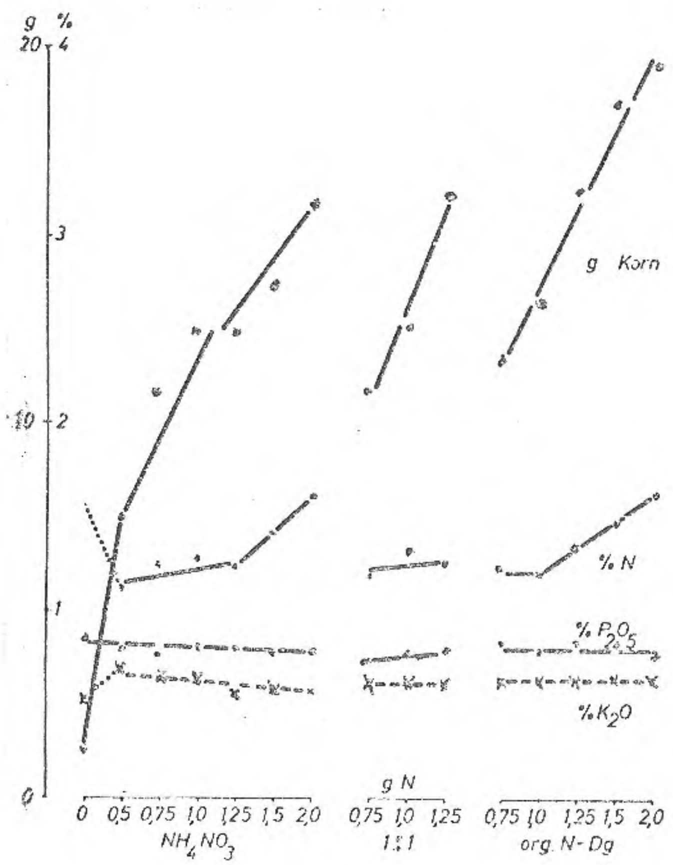

Fig.13: The yield of summer wheat (grain)in chernozem in an experiment with leaching (1961).

N-lignin is bearly completely soluble in water or dispersable. Granulates become dissolved by the influence of soil humidity or by precipitation in short time. During the process of dissolution, at first parts of N-Lignin dissolved have a larger amount of available nitrogen and lower amount of difficultly available nitrogen. The part which is dissolved finally contains nearly only organically bound nitrogen. It is proposed that the less solubility and the relatively high part of high molecular weight substances with exchange properties diminish. The displacement of nitrogen of this fertilizer by leaching. One reason for less leaching is also the inhibition of nitrification.

In pot experiment with chernozem (Fig. 12) wheat was planted with increasing amount of Ammonium nitrate, N-Lignin and a mixture 1:1. The soil was watered in such a way that a small but continuous water flow occurred. Water was added again to the pots. Therefore, the depression can be expected when the nitrogen is removed from the soil.

The yield of plants fertilized with N-Lignin alone were higher even at smaller doses than with nitro-chalk. Higher doses of N-Lignin gave superior yields than mineral fertilisers. The mixture of N-Lignin with Ammonium nitrate behave similarly to N-Lignin alone. The yield has also been higher than in the case of mineral fertilizers. Before, it was reported that the nitrogen content of the plants was lower under normal conditions then this after addition of mineral fertilisers. But in this experiment, the nitrogen content was the same or in some cases higher.

5.2 Experiments in small lysimeters.

Some test experiments about leaching have been made with chernozem and brown earth in small lysimeters. Both the soils have a different sorption capacity.

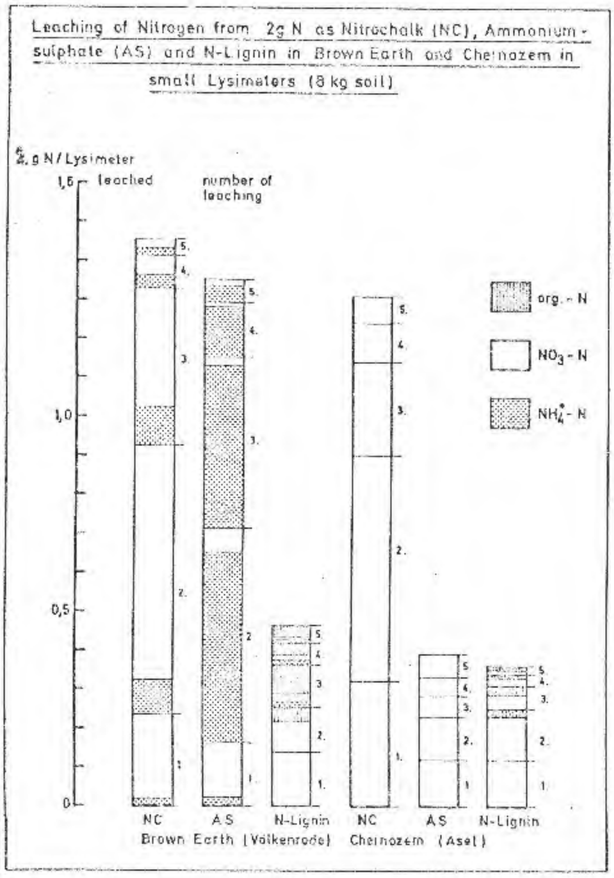

Fig. 14 : Leaching from 2 g of inorganic fertilizers and N-lignin from chernozem and brown earth in small lysimeters (8 kg soil).

The soil was leached five times with 500 ml water. Due to weak sorption capacity of brown earth nearly the same amount of nitrogen from both types of mineral fertilizers such as nitro-chalk and Ammonium sulphate was leached. The sorption capacity of this soil was too small to sorb Ammonium ions. Even under this extreme conditions, the leaching of nitrogen from N lignin is diminished by 60 per cent.

In the case of strongly sorbing chernozem the leaching of nitrogen from N-lignin is less than this of ammonium sulphate. In the case of N-lignin, organic bound nitrogen is also leached.

5.3 Field Experiments

Table 5: Field experiments, Yields of grain in tons/ha. (relatively dry years mean under the condition in Volkenrode having a precipitation of less 600 mm per year, relative wet years more than 750 mm per year.

Time fertilization		rel.dry year			rel.wet year			fertilization in fall	
		B.2.	M.3	M.3/M.5	B.2.	M.3.	M.3/M.5	M.11.	M.11./M.3
KgN/ha	as								
70	NC	3,59	3,60	3,63	2,45	2,47	2,53	2,65	2,84
	1:1	-	3,45	-	-	2,69	-	2,80	2,98
	N-Lignin	3,49	3,22	-	2,54	2,50	-	3,14	3,12
105	NC	3,72	3,92	3,97	2,56	2,56	2,66	3,00	3,42
	N-Lignin	3,77	3,67	-	2,72	2,61	-	3,52	3,69
140	NC	-	3,82	-	-	2,78	2,89	-	-
	1:1	-	-	-	-	2,93	-	-	-
	N-Lignin	-	-	-	-	3,13	-	-	-

NC = Nitrochalk B = Beginning
M = Middle

The results of field experiments on a light soil (loamy sand) which have been conducted during several years have been summarised in such a way that the middle values of grain yield in ton per hectare are given in relatively wet or dry years for different amounts of fertilizer. Different times of fertilization were chosen in different years to study different rate of mineralisation of N-lignin, to investigate the dependence of time and leaching of nitrogen from the different fertilizers. For instance, beginning February (B.2) middle of March (M.3) and in the case of nitro-chalk, spilt application middle of March (M.3) and middle of May (M.5). Simultaneously, experiments have been made, if nitrogen fertilization with N-Lignin is possible at the same time with local usual fertilisation with phosphate and potasium in autumn (middle November = M. 11.). (Right site of the Fig.). In the case of nitro-chalk a small increase of yield was observed by later use of the fertilizer in relatively dry as well as relatively wet years and by fertilisation in spring. This increase can not be explained by a diminition of leaching. The yields with N-lignin and its mixture with nitro-chalk in ratio 1:1 have been lower than with nitro-chalk alone in relatively dry years at low doses of fertilisers. A distinct increase of yield with N-lignin can be observed by early use of this fertiliser. Earlier use of N-lignin was also found more favourable than later in relatively wet years. Fertilization with N-lignin and mixed fertiliser is superior to nitro-chalk in wet years in all cases. Especially, superiority of N-lignin can be observed by fertilization in autumn. This difference remains also when the doses of fertilizer is given in two parts in middle of November and middle of March. The diminition of leaching is clearly seen in the case of fertilization with N-lignin in comparison with fertilization with nitro-chalk. The use of N-lignin during autumn seems to be possible also on light soils at not too high precipitation according to these results.

6. Increase of sugar content in sugar beet.

Table 6: Field experiments with sugar beets on loamy sand with N-lignin. Yield of leaves and beets in ton/ha, percentage sugar and sugar yield in ton/ha (Söchtig, un-published).

1962:	Yield to/ha		% Sugar	Yield of Sugar to/ha
Fertilization in fall 180 kg N/ha	Leaves	Beets		
N-Lignin (1 dosis)	17,9	32,8	18,1	5,94
Nitro-chalk (3 dosis)	31,5	25,9	17,2	4,45
Fertilization in spring				
180 kg N/ha				
N-Lignin	25,1	42,6	17,9	7,63
Nitro-chalk	44,4	39,4	17,0	6,70
1963:				
Fertilization in spring 160 kg N/ha				
N-Lignin	21,0	43,2	18,8	8,12
Nitro-chalk	26,2	46,2	17,1	7,90
210 kg N/ha				
N-Lignin	25,9	46,6	18,5	8,63
Nitro-chalk	34,4	48,3	17,0	8,22
1965:				
Fertilization in spring 180 kg N/ha				
N-Lignin	34,1	46,0	18,0	8,28
Nitro-chalk	46,1	45,4	17,2	7,81

In Völkenrode, several experiments have been made with fertilisation of sugar beets with nitro-chalk and N-lignin. In all years and under all conditions, the distinct diminition of the yields of leaves could be observed by fertilization with N-lignin. The yield of beets on the contrast is increased by N-lignin with exception of the year 1963. Also, a distinct increase of percentage of sugar content in the beets can be observed in all the years. Thereby a yield of sugar in ton/ha is also higher in this year, where the yield of beets by fertilization with N-lignin had been lower than with nitro-chalk.

The reason for this findings are not yet completely elucidated. The possible explanation might be, that a more equal distribution of the release of nitrogen and a better nutrition of the plant with phosphate occur.

A further result by which the use of N-lignin for plantation of sugar beets is favourable, is this that the content of the so-called noxious nitrogen-this means the soluble nitrogenous compounds-- are decreased and the extractability of sugar from beets is made easier.

These results have been confirmed also by experiment of the Agricultural Chemical Experimental Station of Austria, Vienna during two years.

7. <u>Final remarks:</u> Even if the results of pot and field experiments were observed mainly under climatic conditions of Braunschweig, they let know us several favourable possibilities of the use of N-lignin. The results from these test experiments established that the

availability of the nitrogen from N-lignin increases under warmer climatic conditions and that the special effect of organic compounds in N-lignin for instance in direction to inhibit nitrification, to increase uptake of phosphate or to increase the resistance against drought can be more observable in warmer climate than under the conditions in middle Europe.

For experiments with N-lignin in your Experimental stations our experiences can be taken up completely the experience from which I reported a part.

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