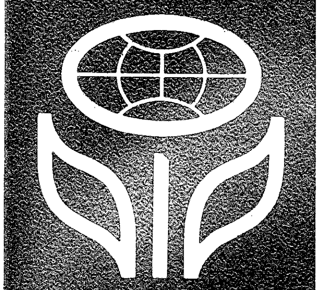

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Nitrogen dynamics in bark compost as dependent on production methods I. Model trials

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NITROGEN DYNAMICS IN BARK COMPOST AS DEPENDENT ON PRODUCTION METHODS

I. MODEL TRIALS

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Abstract

In model trials without plants (25^{o} C, 90 % of water holding capacity), the change of soluble (0.025 N $CaCl_2$) mineral N (NO_3, NH_4) in bark composts was studied for 17 weeks without and with N-application (80 mg N as NH_4NO_3/20 g compost dry matter). 8 bark composts, produced by different fermentation procedures, were compared with sphagnum peat:

4 long-term composts ± N-application for fermentation
3 short-term composts ± N-application for fermentation
1 bark compost from a depot (about 25 years old)
\- N-application

The amounts of C_t varied between 27 and 42 %, N_t between 0.66 and 1.16 % i.dry matter.

Long-term fermented bark composts showed nearly a constant supply of soluble N during the first 10 weeks; lateron the amounts of N_{min} decreased slowly similar to peat (N-fixation). The depot-bark strongly fixed fertilizer-NH_4 (C/N = 47). Short-term composts were very variable in N_{min}-contents (N-fixation and remineralization).

The great differences in nitrification capacity of tested bark composts were independent of method of fermentation respectively pH of compost (pH 5.2-7.6); this may be mainly explained by different degrees of pollution with soil.

1. Introduction

In horticulture, more recently fermented barks - commonly called bark composts - are added to substrates for peat - and container cultures up to 60 % by volume. Bark compost usually is rich in nutrients (K, P, trace elements) - sometimes toxic amounts of Mn are reported (Solbraa and Selmer-Olsen 1981, Scharpf 1981), - and its physical properties are viewed favourable with the only exception of a reduced buffering capacity for water (pF 1.7-2.0) as compared to sphagnum peat (Cappaert et al., 1973). Hoitink (1980) mentions anti-phytophatogenic effects of bark composts.

In culture substrates with higher amounts of bark composts, an optimal N-nutrition of plants is sometimes difficult to achieve, since bark composts can fix nitrogen depending on fermentation methods (e.g. Fischer et al., 1980). According to Zöttl (1981), a nitrogen content of about 1 % is a quality criterion for bark composts with balanced N dynamics. In this investigation it was tested whether total N alone or also the method of fermentation - especially the turnover time (long-term and short-term composts) - should be put forward to assess the quality of bark products with regard to N-turnover.

2. Material and methods

Turnover of N as measured by changes of nitrate and ammonium contents with and without N application was tested on 8 different bark composts and compared with sphagnum peat.

Experimental composts and their preparation (table 1)

TABLE 1 - BARK COMPOSTS - METHODS OF FERMENTATION

MARKING	KINDS OF BARK RESP. METHODS OF FERMENTATION	
peat (=control)		sphagnum peat + lime (2,5 g $CaCO_3$/l) + trace elements (75 mg Flory 1o/l)
LC 2	oak	- fermentation for 24 months: no N
LC 3	7o % spruce 3o % pine	- 8 months pre-composting, 3 months controlled fermentation: 1,5 g N as urea/l - o,5 g N as Crotodur/l
LC 4	85 % spruce 15 % pine	- 8 months pre-composting, 2 1/2 months controlled fermentation: 1,4 g N as urea/l
LC 5	conifers	- 9 months fermentation (8-1o times mixing): 1,o g N as urea/l
DC 6	conifers	- from a depot - about 2o-35 years old: no N
SC 7	spruce	- fermentation with principle "Ufheil": 4o minutes, + about 4 g N_t as chicken-manure/l; about 5 weeks post -composting
SC 8	spruce	- fermentation with principle "Tepe": 1 week, + o,9 g N as $Ca(NO_3)_2$ + 2 g CaO + 6 mg Cu as $CuSO_4$/l be stored for 6 months in plastic bag
SC 9	like SC 8	- but + 12 mg Cu + 4 mg Fe as Fe-chelat be stored for 4 weeks in plastic bag

LC=LONG-TERM COMPOST/SC=SHORT-TERM C./DC=C. FROM A DEPOT

Incubation trial: 20 g dry matter of bark compost resp. sphagnum peat/pot (viz. Zöttl, 1981)
series 1: without N
series 2: 80 mg N as NH_4NO_3/pot

All samples were incubated at 70 % of their max. water capacity in a growth chamber with 25° C and 80 % relative humidity (pots were covered with "parafilm"). After 1 day, 1, 2, 3, 5, 7, 10, and 17 weeks N_{min}-nitrogen (NO_3, NH_4, partly NO_2) soluble in 0.025 N $CaCl_2$ was determined. Since chemical analysis of these composts showed in some cases high contents of Cu and N_{min}, N-turnover was tested on some selected samples with addition of Cu und lower N-application (40 mg N/pot).

Analytical methods for composts

- Volume-weight, pH, salinity, CAL-P_2O_5 and -K_2O, Mg, Mn, Fe, Zn, Cu in 0.5 M EDTA acc. to VDLUFA-methods
- C_t by means of thermic ashing (550° C)
- N_t acc. to Kjeldahl
- Mn in 1 N $MgSO_4$ (substrate/solvent = 1/10)
- N_{min} = soluble mineral N

$CaCl_2$-extraction (substrate/solvent = 1/10)
determination of NH_4 by destillation, of NO_3 by destillation after reduction with Arnd's alloy, partly also by means of HPLC (together with NO_2)

3. Results

Physical and chemical analysis of bark composts (table 2)

Bark composts showed weights of volume between 520 and 750 g/l fresh matter and C-contents of 25 up to 42 % (table 2). Excepting the bark compost from a depot, N_t contents were generally above 0.8 % with maximum values of 1.1 and 1.2 % i. D.M. C/N-ratios differed between 28 and 52 independent of production methods, as well as pH-values varying from 5.2 up to 7.6. Short-time composts showed somewhat higher salinities (e.g. no. 7: addition of poultry manure = high K-contents); with the exception of the latter K-contents differed only little, P-contents to a partly greater extent. Among heavy metal data, $MgSO_4$-extraction of Mn differentiated distinctly in contrast to EDTA-extraction (high values for the short-term composts 7 and 9), and altogether greater differences for Cu- and

TABLE 2 - PHYSICAL AND CHEMICAL CHARACTERISTICS OF BARK COMPOSTS

COMPOSTS	VOL. WEIGHT g/l	DRY MATTER %	C_T	N_T	C/N	PH	SOLUBLE N (mg/l)		
			% I. DRY MAT.				NO_3	NH_4	SUM = N_{MIN}
peat	240	37	-	-	-	5.5	5	35	40
LC 2	750	35	25	0.88	28	6.9	5	10	15
LC 3	690	34	33	0.84	39	7.0	5	200	205
LC 4	580	42	38	0.85	45	6.3	170	80	250
LC 5	610	39	35	0.93	38	5.9	230	20	240
DC 6	740	42	31	0.66	47	7.1	0	15	15
SC 7	520	38	37	1.16	32	5.2			270
SC 8	590	31	39	1.09	36	7.6	520	20	540
SC 9	650	27	42	0.81	52	7.2	60	10	70

TABLE 2 -CONTINUED

COMPOSTS	CAL		EDTA	$MgSO_4$	EDTA				SOLUBLE SALTS
	P_2O_5	K_2O	MN	MN	MG	FE	ZN	CU	g/l
	mg/l		mg/l			mg/l			
peat	12	7	-	-	-	-	-	-	0.2
LC 2	40	345	190	< 1	90	250	8	1.5	0.40
LC 3	55	400	310	15	173	410	32	9	0.95
LC 4	50	400	170	10	133	183	12	1.2	0.70
LC 5	140	500	190	5	128	207	12	1.2	1.20
DC 6	45	205	265	3	118	318	30	4.4	0.65
SC 7	280	705	210	190	183	104	29	0.7	2.30
SC 8	90	350	265	38	100	22	20	13	2.70
SC 9	65	415	275	170	143	44	23	8	1.20

Zn-contents have to be mentioned (partly caused by addition for fermentation as known for no. 8 resp. by pollution). High variations of N_{min}-contents with partly high amounts of NO_3 resp. NH_4 have to be pointed out. Contents were dependent on N-addition and nitrification capacity of the composts to a greater extent than on the fermentation process (viz. later).

N-turnover in incubation trials

In figures 1 and 2 changes of soluble mineral nitrogen (sum of $NO_3 + NH_4$) with and without additional N-fertilization are shown in relation to incubation time.

Long-term composts (fig.1) altogether exhibited a more stable nitrogen curve, very similar to peat on the given starting level; only when N was added, N contents of composts 2, 5, and peat decreased after 10 weeks, in most cases caused by a reduction of NO_3-content (viz. later = biological N-fixation). In contrast, N-contents of short-term composts varied to a greater extent especially with N-fertilization (fig.2). Compost 9 (0.81 % N_t, $C/N \doteq 52$) showed in both series (fermentation - as well as fertilizer-N) a quick and marked blocking of N; after 8 weeks, however, mineralization = release of mineral N recommenced. Compost 7 (1.16 % N_t, C/N = 32) fixed the total given amount of fertilizer (80 mg N/20 g D. M.) within the first 4 weeks; in series without additional application only minimal N_{min}-amounts were left after 1 day.

Relatively stable proved compost 8 with by far highest amounts of N_{min} in both series (1.09 % N_t, C/N = 36).

The bark compost from a depot (no. 6: 0.66 % N_t, C/N = 47) was relatively free of soluble nitrogen similar to peat, but did fix more N in the beginning.

Fig. 3 shows a N balance-sheet drawn from these results. The amounts of N_{min}-nitrogen calculated in the series with N-addition, by taking into account the control values (compost without N-addition), are plotted as positive resp. negative value on the ordinate if there was an increase resp. decrease with respect to the applied N level (80 mg N = 0 on the ordinate).

Long-term composts, similar to peat, showed altogether only slight changes of the N-level set by N-fertilization; after about 7 to 10 weeks supply of soluble N decreased in most cases. The available amount of N in short-term composts, however, varied strongly between extreme N-fixation in the beginning (compost 7, 9, 6) followed by remineralization (composts 9, 6). In contrast with compost 8 amounts of N_{min} increased after a 5 week lag - phase above the given N-level and decreased after the 10th week very pronouncedly as consequence of N-fixation.

Sphagnum peat did not have any nitrification activity, neither did long-term compost 3 (minimal nitrification only after the 10th week) (fig.4) in contrast to composts 2 and 5 (fig.5: high activity) resp. compost 4 (fig.4: low activity).

Starting with the 10th week, NO_3-contents decreased more or less clearly probably as consequence of a biological blocking. In the bark compost from a depot (compost 6) an immediate NH_4-fixation was observed (biological, partly chemical), nitrate contents stayed nearly on the starting level (fig.6) - minimal nitrification took place.

The given NH_4 - and especially NO_3-nitrogen was rapidly fixed in the short-term composts obviously mainly by micro-organism (fig.6 and 7); in contrast to product 7, heavy mineralization to nitrate took place in compost 9 starting with the 7th week (good nitrification capacity). Compost 8 did not show any appreciable amount of nitrification activity; applied NH_4-fertilizer stayed unchanged during the whole incubation time; the result was the same with half the amount of N applied (40 mg N/20 g D. M.), which implies that high NO_3 - resp. salt contents should not inhibit NH_4-oxidation. The question of correlations between Cu-supply and nitrification capacity was tested in an additional experiment with compost 2; Cu-application did not change any nitrification characteristics of this compost, so that the lacking nitrate oxidation in compost 7 could not be attributed to its high Cu-content (13 mg/l, viz. tab.2) (fig.5).

4. Discussion

This incubation trial clearly differentiates N-turnover in long-term and short-term composts. Long-term composts largely exhibited the same N dynamics (amounts of N_{min}) as sphagnum peat with some variation in nitrification capacity; type of bark (conifer - or oak) did not influence N-turnover.

Short-term composts showed partly erratic changes of NO_3- and NH_4-nitrogen with or without additional N-fertilizing. Sometimes rapid biological nitrate fixation (2nd - 5th week) was followed by a similarly distinct N-mineralization (7th - 17th week) up to nitrate. These very instable N-dynamics - fixation as well as remineralization-cannot be predicated satisfactorily by the parameters total N content or C/N-ratio of the composts. Strongly N-fixing composts sometimes had N_t-contents of more than 1 % and C/N-ratios of about 35.

Thus, the results by Zöttl (1981) could not be verified. Only in the case of bark compost from a depot, it was possible to predict blocking of N by N_t-content (0.66 % i. D. M.) and C/N-ratio (47). Obviously, besides N-content (N_t and N_{min}) the amount of easily decomposable organic matter becomes very important with regard to N-turnover; in long-term composts it should be clearly less than in the examined short-term composts resulting in more favourable N-dynamics (Teicher et al., 1984). Nitrification capacities of the test composts - sphagnum peat did not have any activity - did not correlate either with pH or with fermentation procedures (long - or short-term) and may be explained mainly by varied degrees of pollution with soils or possibly by residual inhibitors like tannins, essential oils and so on.

In conclusion, besides total-N and C/N-ratio, data about fermentation procedures, especially turnover time, should be of great importance to assess the applicability of fermented bark for horticultural substrates.

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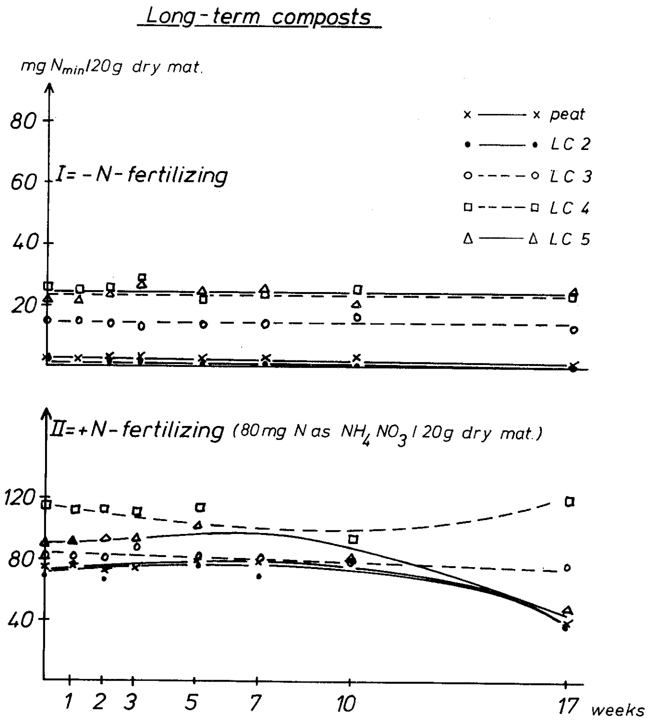

Fig. 1 - Incubation trial with bark composts - Changes in N_{min} ($NO_3 + NH_4$)

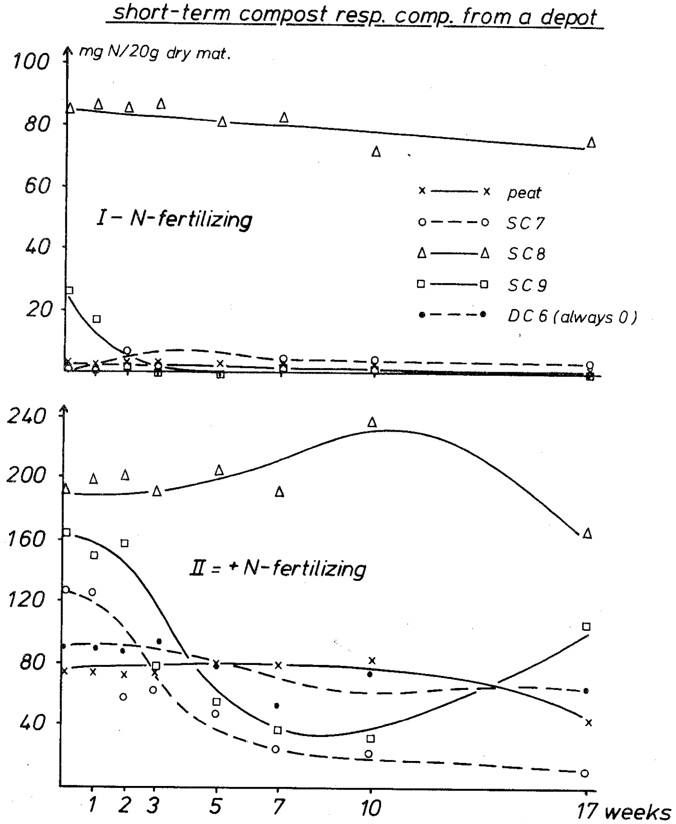

Fig. 2 - Incubation trial with bark composts - Changes in N_{min} ($NO_3 + NH_4$)

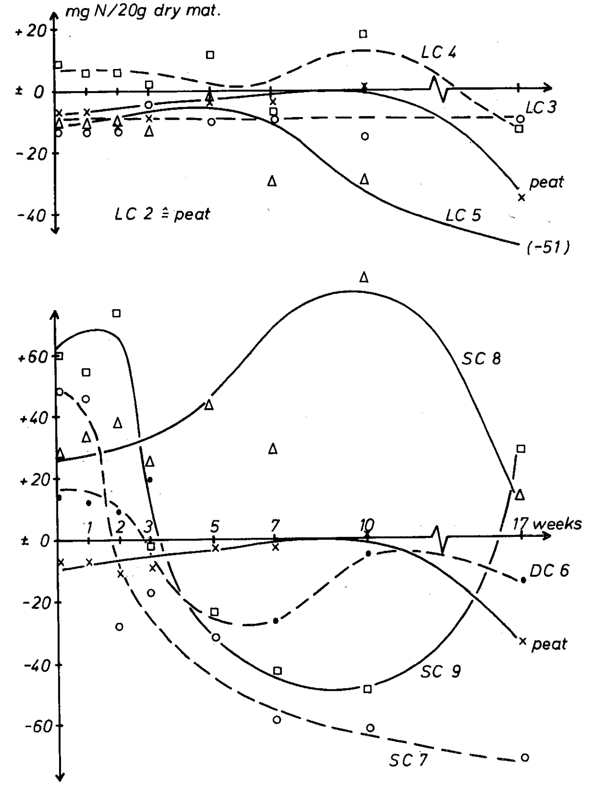

Fig. 3 - Incubation trial with bark composts - Changes in N_{min} (ΔN compared with control = compost without N-fertilizing) fertilized N (80 mg N/pot) ≙ 0 of the y-axis

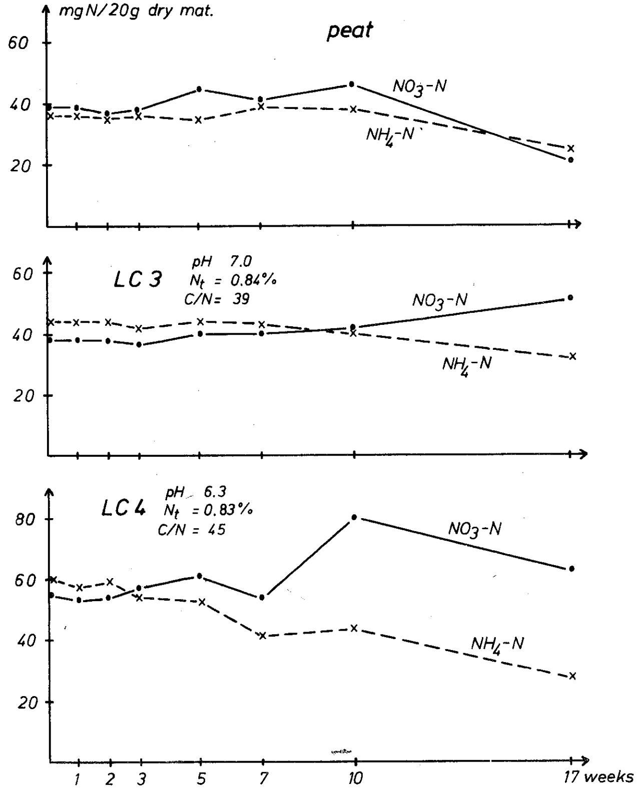

Fig. 4 - Incubation trial with N-fertilizing - Changes in $CaCl_2$-soluble NO_3 and NH_4

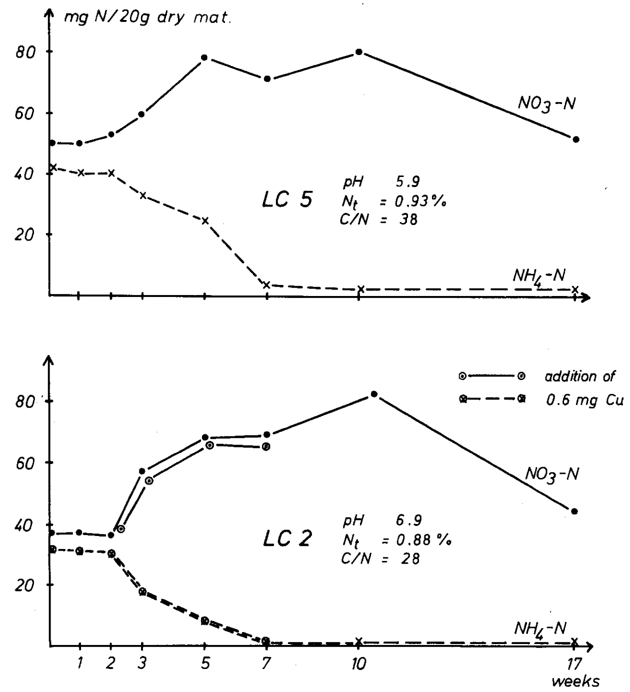

Fig. 5 – Incubation trial with N-fertilizing – Changes in $CaCl_2$-soluble NO_3 and NH_4

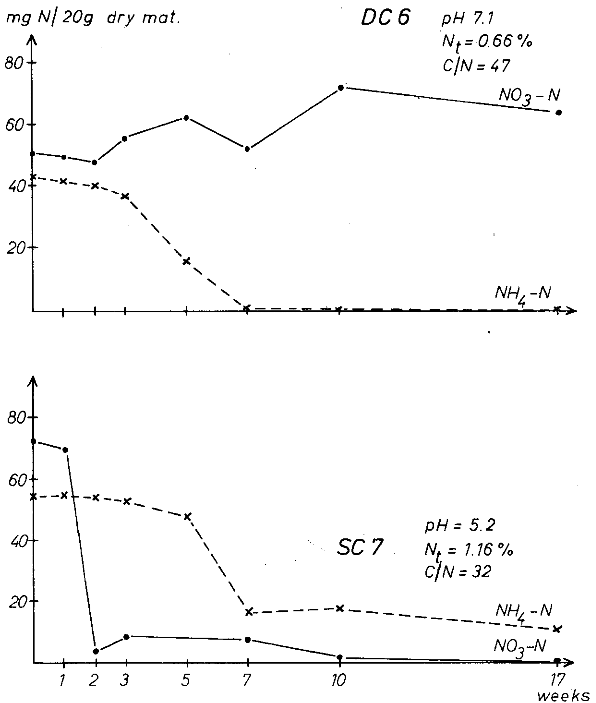

Fig.6 - Incubation trial with N - fertilizing - Changes in $CaCl_2$ - soluble NO_3 and NH_4

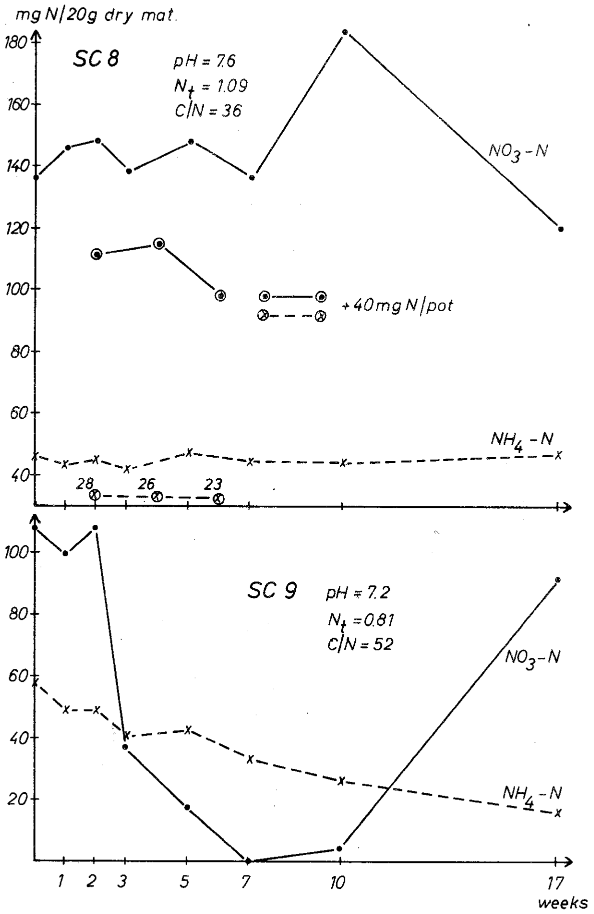

Fig. 7 - Incubation trial with N-fertilizing - Changes in $CaCl_2$ - soluble NO_3 and NH_4