pressing a wide range of pathogens The primary effect of these products is based on the establishment of the beneficial fungi in the growth media before the pathogen can develop into a problem Therefore, the growth medium has to be treated as early as possible

Supresivit is an example of a registered product containing the beneficial fungi *Trichoderma harzianum*. Supresivit contains 1.4×10^{10} spores per gram. This high concentration of spores makes it possible to distribute the product very evenly in, for instance, peat. The high concentration together with a broad spectrum effect makes Supresivit a very suitable product for incorporation into growth media.

Cabbage Seedlings Grown Organically in Plugs — Substrate Liming and Fertilizer Supply

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INTRODUCTION

Organic vegetable production in Denmark has increased rapidly during the last decade In 1997, the acreage of organic horticultural crops — mainly vegetables — had increased to 769 ha Accordingly, there is a demand for development of propagation methods with special emphasis on organic farming

In Danish propagation nurseries, it is common practice to raise seedlings of cabbage in plug trays filled with sphagnum peat In organic farming, sphagnum peat is usually mixed with limestone and an organic fertilizer. Besides the ability to increase pH of the peat, limestone is an important calcium source If dolomitic limestone is chosen, a large quantity of magnesium is added at the same time as dolomitic limestone contains about 10% magnesium

The main purpose of the present study was to assess optimum quantities of dolomitic limestone and fertilizers as additives to sphagnum peat used as a propagation substrate for seedlings of white cabbage raised organically in plug trays. Due to the small volume of plugs it may be necessary to supply extra fertilizer to the plug plants during the propagation period In the present study, it was investigated whether it is feasible to use diluted recirculated or nonrecirculated liquid cattle manure as a supplementary fertilizer.

EXPERIMENTS WITH SEEDLINGS OF WHITE CABBAGE

Two experiments with organically grown seedlings of white cabbage (*Brassica oleracea* L Capitata Group 'Bartolo') were carried out to investigate the possibilities for improved fertilization during germination and subsequent growth in plug trays under glasshouse conditions Each plug tray (60 cm × 40 cm, VEFI A/S), with 54 conical plug cells, each 90 cm^3 and 6.5 cm high, constituted one plot The seeds were sown on 10 Aug. 1995 (Experiment 1) and 18 April 1996 (Experiment 2) and the experiments were terminated 27 or 25 days after sowing, respectively. The treatments were replicated twice in Experiment 1 and three times in Experiment 2

In Experiment 1, comparisons were made between different quantities of dolomitic limestone (2, 4, 6 or 8 kg m^{-3}) and composted poultry manure (10, 30, or 50 liters m^{-3}) incorporated into the plug substrate which basically consisted of sphagnum peat (75% light and 25% dark sphagnum peat, particle size up to 10 mm, pH 4 1, Pindstrup Mosebrug A/S). The manure had been composted for 1 to 2 years and thereafter dried and finely screened (manufactured by Farmergødning ApS).

In Experiment 2, one of the best mixes from Experiment 1, with a content of 6 kg dolomitic limestone and 10 liters manure m^{-3}, was compared with Bina-muld, a commercial standard mix manufactured in Denmark by Binadan A/S Bina-muld consists of light sphagnum peat (particle size up to 30 mm) mixed with dried, noncomposted poultry manure, calcium carbonate, dolomitic limestone, and glacial clay (19, 2 5, 0.9, and 32 kg m^{-3} peat, respectively).

All treatments were irrigated on ebb-and-flood benches with a solution of dilute cattle manure, and there was one separate solution for each plot In Experiment 1, the solutions were applied from 14 days after sowing and all of the solutions were recirculated In Experiment 2, they were applied from 7 days after sowing and comparisons were made with plants irrigated with a similar solution that was not recirculated Recirculated as well as nonrecirculated nutrient solutions were diluted with rain water (pH 6.8) to initial concentrations of 7 mmol $liters^{-1}$ N (100 ppm, the half of it as ammonium N, the other half as organic N) and 3 mmol $liters^{-1}$ K (120 ppm). Further details of the experimental procedures are described by Willumsen (1999).

LIME AND FERTILIZER RATES

In Experiment 1, maximum plant growth was achieved in a substrate mix with 10 liters of composted poultry manure and 4 to 8 kg dolomitic limestone m^{-3} peat (Table 1). Higher quantities of manure and a lower quantity of dolomitic limestone reduced plant growth.

The electrical conductivity in the substrate, as a measure of the total concentration of available major nutrients, was highest, as expected, at the highest fertilizer level (Table 1). Very little nitrate was found in the substrate mixes after 27 days of propagation (Table 1). Almost all accessible N was present as ammonium Apparently, the nitrification process in the substrates was too inefficient to increase the nitrate concentration. It is suggested that depressed growth occurred as a result of high ammonium and very low nitrate concentrations in the substrate promoting ammonium toxicity in the plant as found in earlier studies (Ikeda and Yamada, 1984; Pill and Lambeth, 1977).

Increased application of dolomitic limestone prior to sowing did only slightly increase the pH of the substrate as shown in Table 1, which also shows that pH increased during the experiment However, the increases during the propagation period were moderate taking into consideration that pH of all recirculated nutrient solutions of liquid manure simultaneously increased from about 7 3 to 8 2 It appears likely that the buffering capacity of the peat mixes in the plug cells, despite their small volume, together with the supply of liquid manure, forcing plants and microorganisms to take up nitrogen almost exclusively as ammonium with release of protons as a result, were able to keep pH of the plug mixes between 5 and 7

Table 1. Experiment 1 at the end of the propagation period (27 days from sowing): pH, electrical conductivity (EC), and concentrations of ammonium N and nitrate N in the plug substrates. In addition, fresh and dry matter of aerial plant parts and root density alongside the pot (rated 0 to 5) as affected by the amount of poultry manure and dolomitic limestone mixed into the plug substrate. pH at sowing (Day 0) is also shown.

Treatments:	pH		EC	NH_4-N	NO_3-N	FM[X]	DM[Y]	Root density
	day 0	day 27	mS cm^{-1}	(mmol l^{-1})		(g $plant^{-1}$)		(0-5)
Manure (liters m^{-3})								
10	5.4	6.4	1.4	1	0.1	4.3	0.32	5.0
30	5.5	6.4	1.9	8	0.5	4.0	0.25	4.1
50	5.5	6.4	2.8	24	0.6	2.7	0.15	2.5
$LSD_{.05}$	-	-	0.5	6	-	0.4	0.03	0.4
Limestone (kg m^{-3})								
2	5.1	6.0	2.2	15	0.1	2.8	0.17	3.7
4	5.4	6.4	2.0	11	0.2	3.9	0.26	4.0
6	5.6	6.5	1.8	9	0.5	3.9	0.26	3.8
8	5.7	6.7	2.2	9	0.7	4.1	0.28	4.0
$LSD_{.05}$	0.2	0.3	-	-	-	0.5	0.03	-
Significance:								
Manure	ns[Z]	ns	***	***	ns	***	***	***
Limestone	**	**	ns	ns	ns	***	***	ns
Man. × limestone not estimable (pooled samples)				ns	ns	ns		

[X] FM = fresh matter.
[Y] DM = dry matter.
[Z] ns, **, ***: nonsignificant and significant at $p < 0.01$ and < 0.001, respectively.

Table 2. Experiment 2. The effect of plug substrate and recirculation of the supplementary solution of dilute liquid cattle manure on pH, electrical conductivity (EC), and concentrations of ammonium N and nitrate N in the substrate and in the supplementary solutions at the start (Day 0, in substrate only) and end (Day 25) of the propagation period, and on fresh and dry matter of aerial plant parts.

Substrate	Recirculation	pH	EC ($mS\ cm^{-1}$)	NH_4-N ($mmol\ liter^{-1}$)	NO_3-N	FM[X] ($g\ plant^{-1}$)	DM[Y]
Day 0:							
Bina-muld		6.2	1.5	7.6	0		
Selected mix		5.8	1.5	6.5	1.4		
Day 25:							
Suppl. solution	without	8.0	1.5	5.8	0		
(mean of substrates)	with	7.8	1.4	5.7	0		
Bina-muld	without	6.9	1.1	0.6	0	3.4	0.25
	with	6.8	1.2	0.6	0	3.6	0.28
Selected mix	without	6.7	1.1	0.7	0.4	4.4	0.36
	with	6.6	1.3	0.9	0.4	3.7	0.32
Significance on Day 25:							
Substrate		ns[Z]	ns	ns	**	**	***
Recirculation		ns	*	ns	ns	ns	ns
Substrate × recirculation		ns	ns	ns	ns	*	*

[X] FM = fresh matter.

[Y] DM = dry matter.

[Z] ns, **, ***: nonsignificant and significant at $p < 0.01$ and < 0.001, respectively.

RECIRCULATION AND COMPARISON WITH A COMMERCIAL SUBSTRATE

In Experiment 2, Bina-muld and a selected mix from Experiment 1 were compared. It was further tested whether recirculation of the supplementary nutrient solution had any impact on plant growth compared with free drainage from the bench.

Table 2 shows that pH, EC, and the concentration of ammonium N were almost similar in the two mixes, whereas nitrate N was present in the selected mix, but absent in Bina-muld due to the content of noncomposted poultry manure in Bina-muld. The absence of nitrate may explain the differences in fresh and dry matter of plants grown in the two substrates. However, the differences were only significant when the supplementary nutrient solution was nonrecirculated. It appears likely that the recirculation promotes an aeration of the nutrient solution or a balance of microorganisms that counteracts the risk of possible phytotoxic short-chain fatty acids, primarily acetic acid, that may develop when noncomposted manure is applied (Shiralipour et al., 1997). No differences in root growth were visible.

CONCLUSIONS

- Ten liters of dried, composted poultry manure m^{-3} sphagnum substrate gives a higher root density and bigger plants than 30 or 50 liters m^{-3}.
- The optimum rate of dolomitic limestone is 4 kg or more m^{-3} sphagnum substrate.
- Supplementary additions of nitrogen may be necessary because of a low nutrient capacity in the small plugs. Irrigation with dilute liquid manure from cattle is an acceptable possibility. Supplementary additions seem to be a better solution than the addition of a high quantity of an organic fertilizer to the propagation substrate prior to sowing.
- Irrigation with a recirculated nutrient solution may be as good and sometimes better than irrigation with a nonrecirculated solution.

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