Influence of cropping and fertilization on soil pore characteristics in a long-term field study

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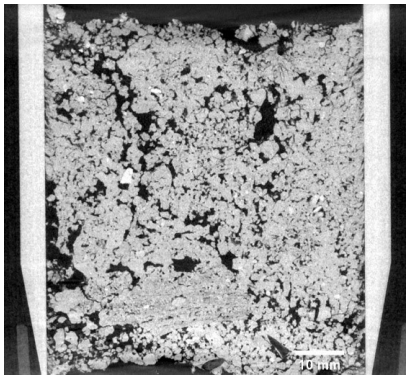
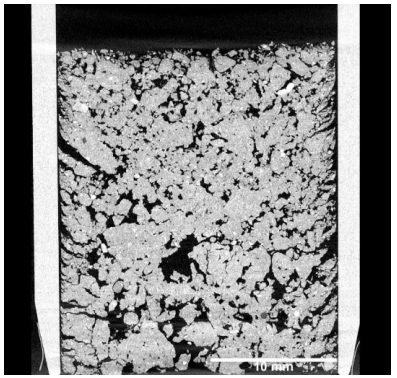
Motivation and aim

- Larger porosities and well connected pores are beneficial for crop growth as they improve availability of oxygen, water and nutrients
- Additions of organic amendments are generally associated with larger porosities and better connected pore-networks
- Mineral fertilizer is often claimed to lead to degraded pore networks
- Bare fallows should lead to heavily degraded pore-networks due to the lack of carbon and reduced biological activity

In this study, we used X-ray microtomography to investigate the pore space properties of the three contrasting treatments in a long-term fertilization experiment in Sweden started in 1956:

- bare fallow
- mineral fertilizer (calcium nitrate)
- farmyard manure (FYM)





Material and methods

E 60	D 59	B 58	C 57	F 56	A 55	G 54	O 53	M 52	L 51	H 50	J 49	K 48	I 47	N 46
M 31	L 32	J 33	O 34	H 35	N 36	I 37	K 38	G 39	E 40	C 41	B 42	F 43	A 44	D 45

N 30	H 29	I 28	K 27	L 26	J 25	M 24	O 23	A 22	F 21	E 20	B 19	D 18	C 17	G 16
A 1	B 2	C 3	D 4	E 5	F 6	G 7	H 8	I 9	J 10	K 11	L 12	M 13	N 14	O 15

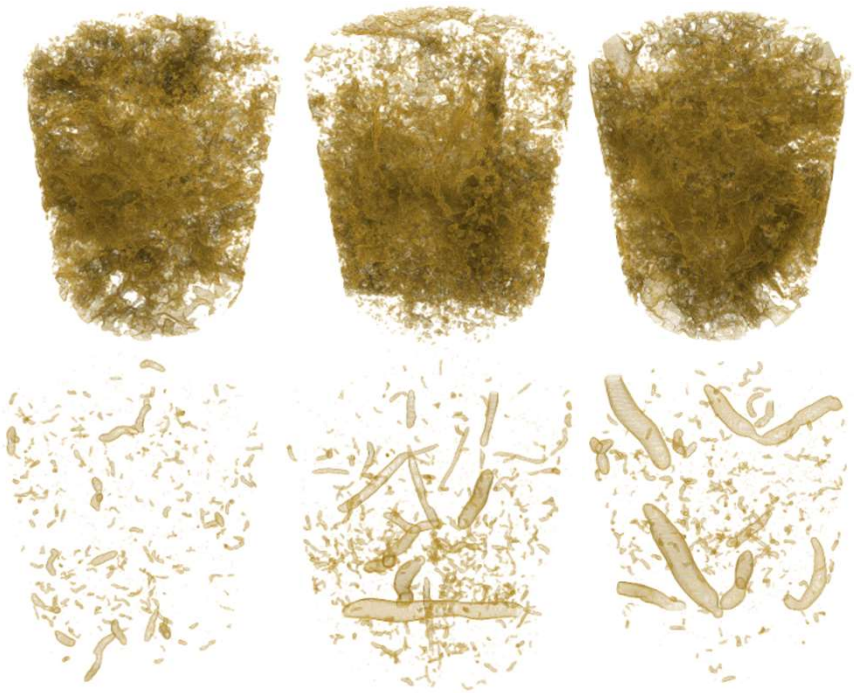
The experiment consists of 2 by 2 meter plots. Each treatment is replicated 4 times.
A – bare fallow
C – calcium nitrate
J – farmyard manure (FYM)

We sampled each two small (diameter 22.2 and height 25 mm, X-ray voxel edge length: 15 µm)
and two large columns (diameter 65.5 and height 74.8 mm, X-ray voxel edge length: 90 µm) per replicated plot,
i.e. eight small and eight large columns per treatment.

Results and discussion

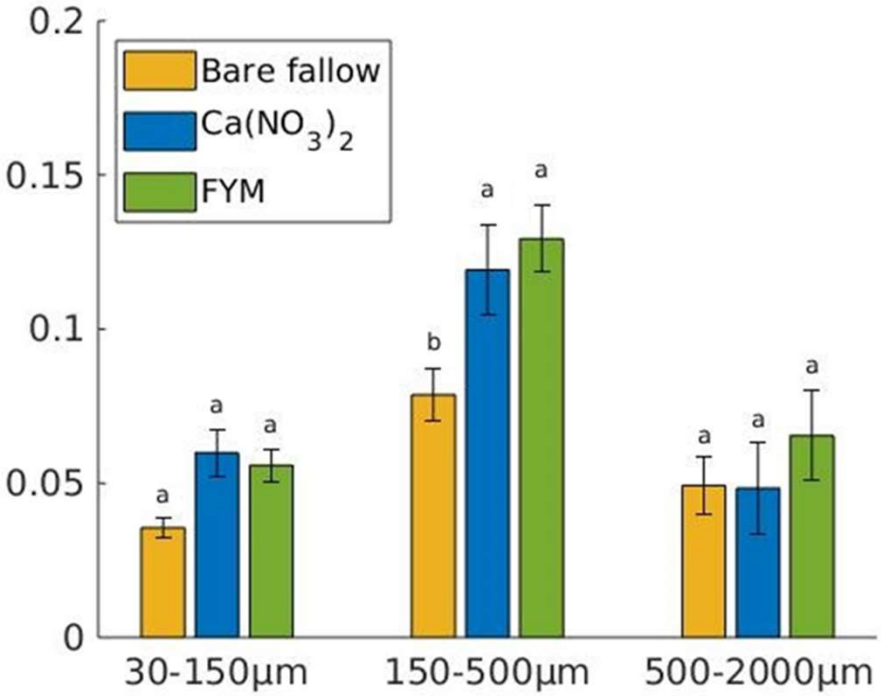
- The image shows examples of the pore and biopore space for the bare fallow, calcium nitrate and farm-yard manure treatments for the large columns

- The biopores in the farm yard manure had the largest diameter



Results and discussion

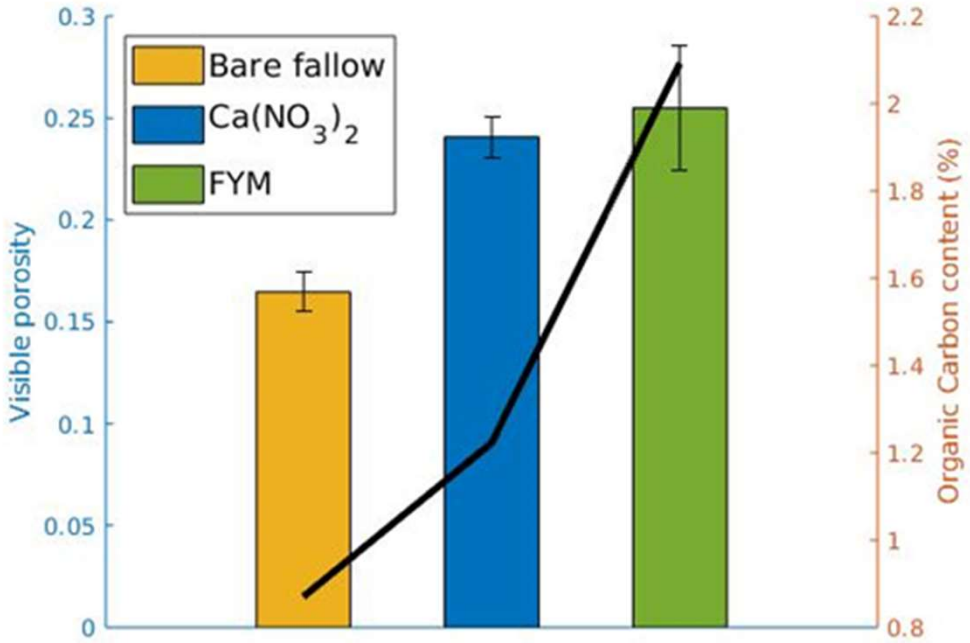
- The visible porosity in the 150-500 µm size class was significantly higher for the calcium nitrate and farm-yard manure treatments compared to the bare fallow.
- A larger difference may have been found if the plots had been managed with heavy machinery instead of by hand.
- Furthermore, the application of the FYM was done almost two years prior to the sampling and fresh organic matter might be more important for the porosity.
- The quality of the manure should also be considered as it could contain high levels of monovalent cations which have a dispersive effect.



Porosities from the small columns of different pore diameter ranges

Results and discussion

- The bars in the graph show the porosity and the line the organic carbon content.
- This increase in SOC content was accompanied with an increase in total porosity when comparing the FYM to the bare fallow, but not compared to the $Ca(NO_3)_2$



Porosities and organic carbon contents of the small columns

Results and discussion

Small columns	Bare fallow	$Ca(NO_3)_2$	FYM
Euler	29707±2677 a	2111±7317 ab	643±4022 b
Gamma	0,88±0,02 b	0,96±0,01 a	0,96±0,01 a
Critical pore diameter (µm)	205±12	221±50	267±32
Surface area connected to top (cm^2)	96± 13	151±22	114±29
Large columns			
Euler	5228±1994	6788±2627	202±3890
Gamma	0,77±0,07 b*	0,90±0,02 ab*	0,93±0,02 a*
Critical pore diameter (µm)	707±130	534±56	820±168
Surface area connected to top (cm^2)	429± 55b	729± 56a	724± 85a

- All connectivity measures indicated that the FYM-treatment had a better connectivity.
- This may be partly because of the larger biopores

Conclusions

- The FYM and calcium nitrate had a higher visible porosity compared to the bare fallow.
- The connectivity measures indicated that the FYM had a higher connectivity
- Calcium compensated for the lower SOC in the calcium nitrate-treatment. Option for improving soil structure without organic amendment.
- Future studies should take the quality of the manure into account