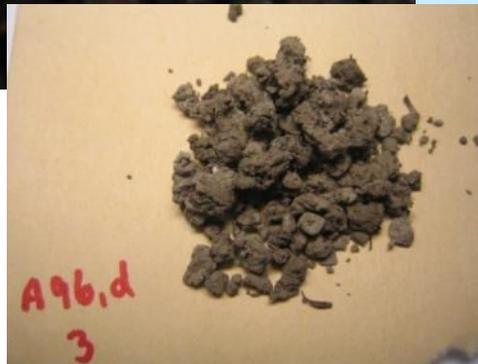


Earthworms : Interactions with management; impacting plant growth

Reidun Pommeresche, A-K.Løes, S.Hansen and H.Riley
NJF, 16.3.2012



Bioforsk =
Norwegian Institute for
Agricultural and
Environmental research



- 20 ha / farm
- 4 % farmed area
- 4 % organically managed
- 2700 organic farms



Cereals
and
vegetables



Milk, meat and grass



- Earthworms in Norway
- Earthworms in different cropping systems
- Earthworms and green manure management
- Earthworms and ploughing
- Nutrients in earthworm casts

Table 1 Earthworm species found in arable soil in in scientific studies from 1987, sites ranked by increasing latitude. Xb= dominant species by biomass, Xn= dominant species by number/density, Xbn = dominant species by both biomass and number/density. X without extra letter = second most common species, x = common species, but found in lower amounts than the dominating species, * = less than three individuals found or less than 1 g m⁻².

Species/Site, year, latitude	<i>A. caliginosa</i>	<i>A. rosea</i>	<i>A. longa</i>	<i>L. rubellus</i>	<i>L. terrestris</i>	<i>A. chlorotica</i>	<i>O. cyaneum</i>	<i>D. rubidus</i>	<i>L. castaneus</i>	Reference
Landvik, 1993 58° 20' N	Xn	*	Xb	x	x	X				Sveistrup <i>et al.</i> 1997
Landvik, 1996	Xb	x	X	X	x	X	*			Bakken <i>et al.</i> 2006
Landvik, 2000	Xb	*	X	x	x	*				Bakken <i>et al.</i> 2006
Voll, Ås, 1993 59° 40' N	Xbn	x	x	x		X				Sveistrup <i>et al.</i> 1997
Voll, 1996	Xb	x	*	X	*	X				Bakken <i>et al.</i> 2006
Voll, 2000	X	x	X	Xb		X				Bakken <i>et al.</i> 2006
Apelsvoll, 1994 60° 42' N	Xn	x	*		x					Engelstad (pers. obs.)
Apelsvoll, 2004	Xn	X		x	x			*		Pommersche (pers. obs.)
Møystad, 2006 60° 47' N	Xn	x		x	Xb					Pommersche (pers. obs.)
Surnadal 1987-89 63° 00' N	Xbn	x		X		*		*		Hansen and Engelstad 1999
Skjetlein, 1991 63° 20' N	Xbn	x	*	X	*					Haraldsen <i>et al.</i> 1994
Kvithamar, 1993 63° 30' N	Xbn	x		X	*	*		*	*	Sveistrup <i>et al.</i> 1997
Kvithamar, 1996	Xb	x		X		*				Bakken <i>et al.</i> 2006
Kvithamar, 2000	Xb	x		X	x	X		*	*	Bakken <i>et al.</i> 2006

Common earthworms in Norwegian agricultural soils



Aporrectodea caliginosa = **Grey worm (Field worm)**, found north to Finnmark 71° N

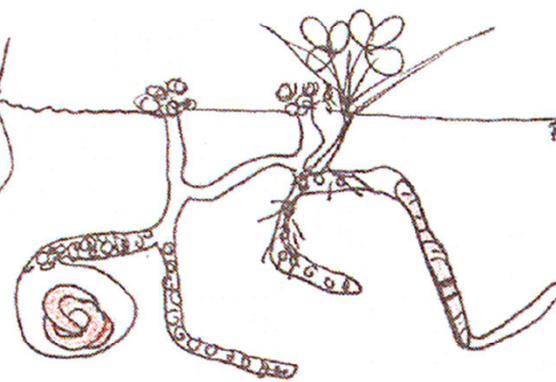
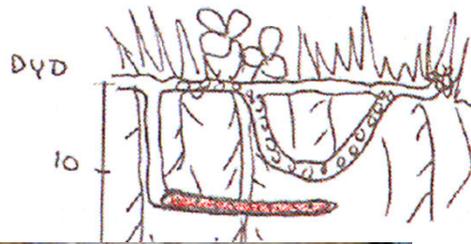
Aporrectodea rosea = **Rosy-tipped worm**, found north to Tromsø 69° N

Lumbricus rubellus = **Red worm**, found north to Finnmark 71° N

Lumbricus terrestris = **Dew worm**, found north to Tromsø 69° N

Økologiske grupper av meitemark

Overflatelevende arter
(skogs- og kompostmeitemark)



Jordlevende arter
(grå og rosa meitemark)



60
70
80
90
cm



Dyptgravende arter
(stor og lang meitemark)



Earthworm distribution



- 30- 350 earthworms/m²
- Grey worm and rosy tipped worm are the dominant species in Norwegian agricultural soils (*Aporrectodea caliginosa*, *A.rosea*)
- We have also found dew worms (*Lumbricus terrestris*) in arable soils, not only perennial ley/meadows
- Grey worm and red worms (*L. rubellus*) are found north to Finnmark
- Dew and rosy-tipped worms are found north to Tromsø 69° N.
- Never found compost worms in field soil (*Eisenia fetida*, *E. andrei*)

How to measure effects on/of earthworms?



- individuals / m²
- biomass (g) / m²
- number of channels/ m²
- species composition
- decomposition rate of straw
- nutrient content in earthworm casts

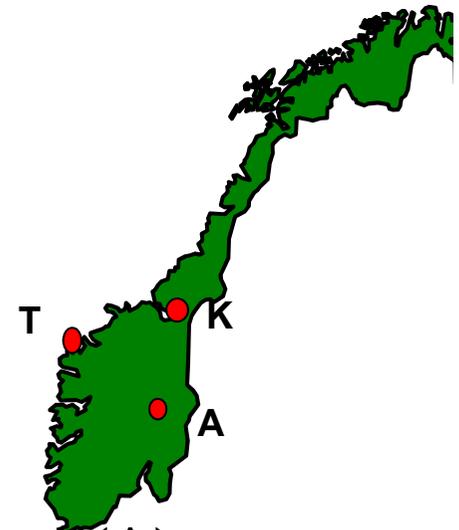


Crop rotation and manuring - effects on earthworms



Long term cropping system experiment at Bioforsk, Apelsvoll (A)

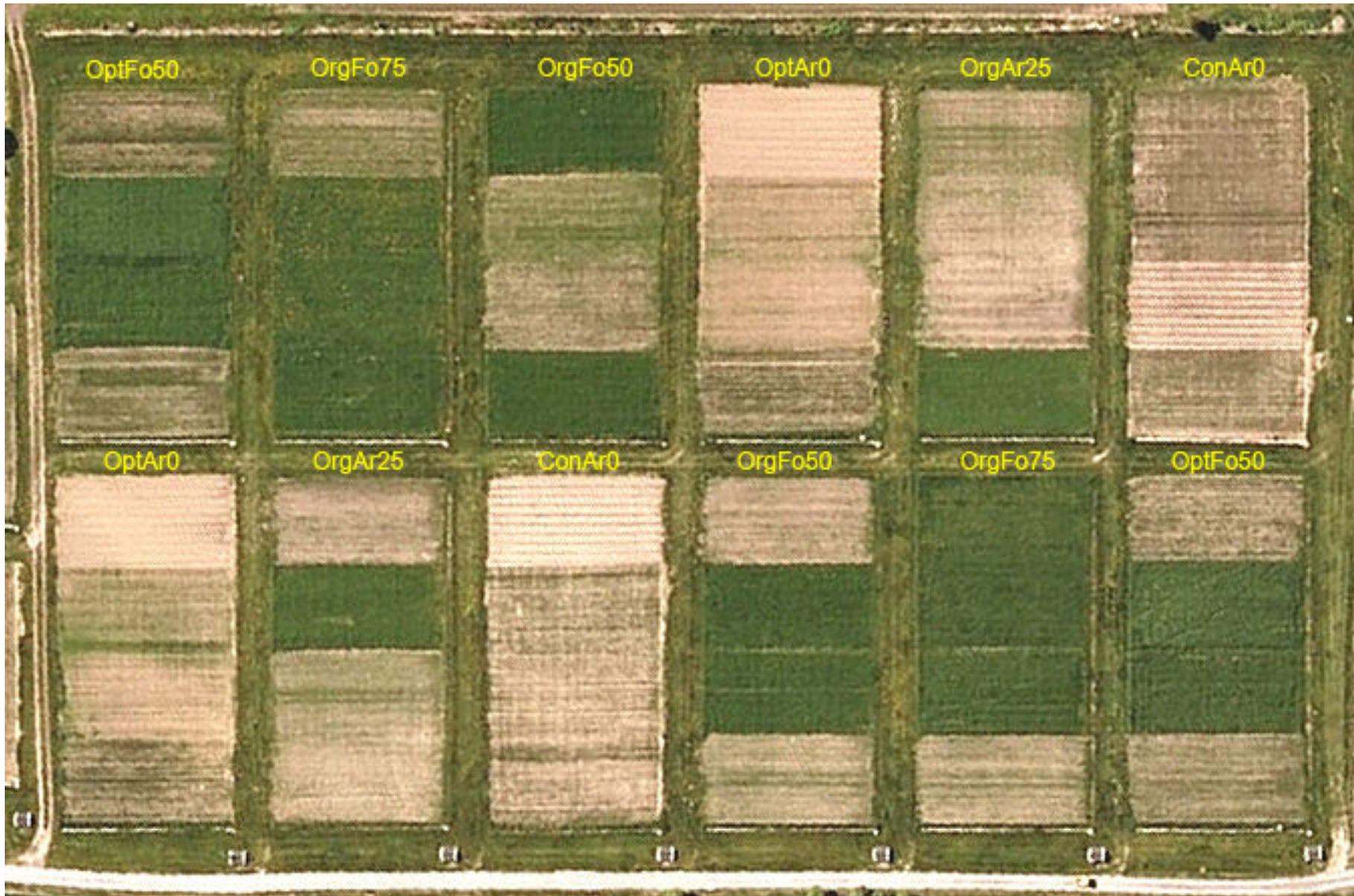
- With/without animal manure
- Conventional/ Organic
- Intensity/portion of grass ley in the crop rotation
- Chemical plant protection and soil tillage
- Moraine soil (loam)
- Started 1987

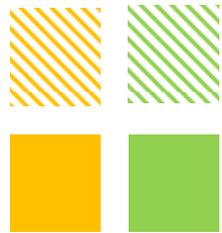


Long term fertilization experiments at Møystad (A)

- Different mineral fertilizers vs solid cattle manure
- Moraine soil (loam)
- Started 1922

Cropping system experiment at Bioforsk, Apelsvoll (A) - the proportion of ley in the crop rotation.

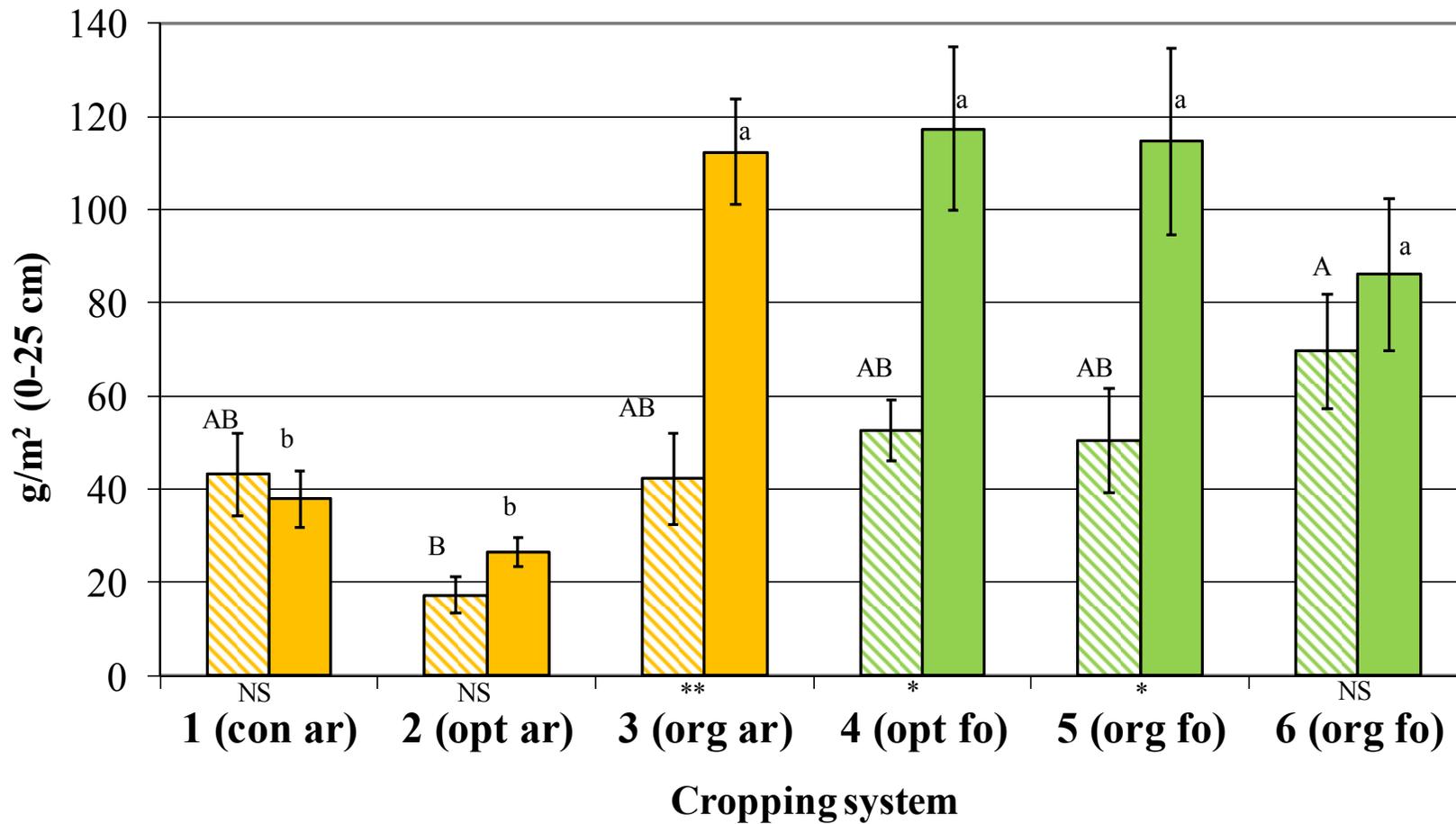




1994

2004

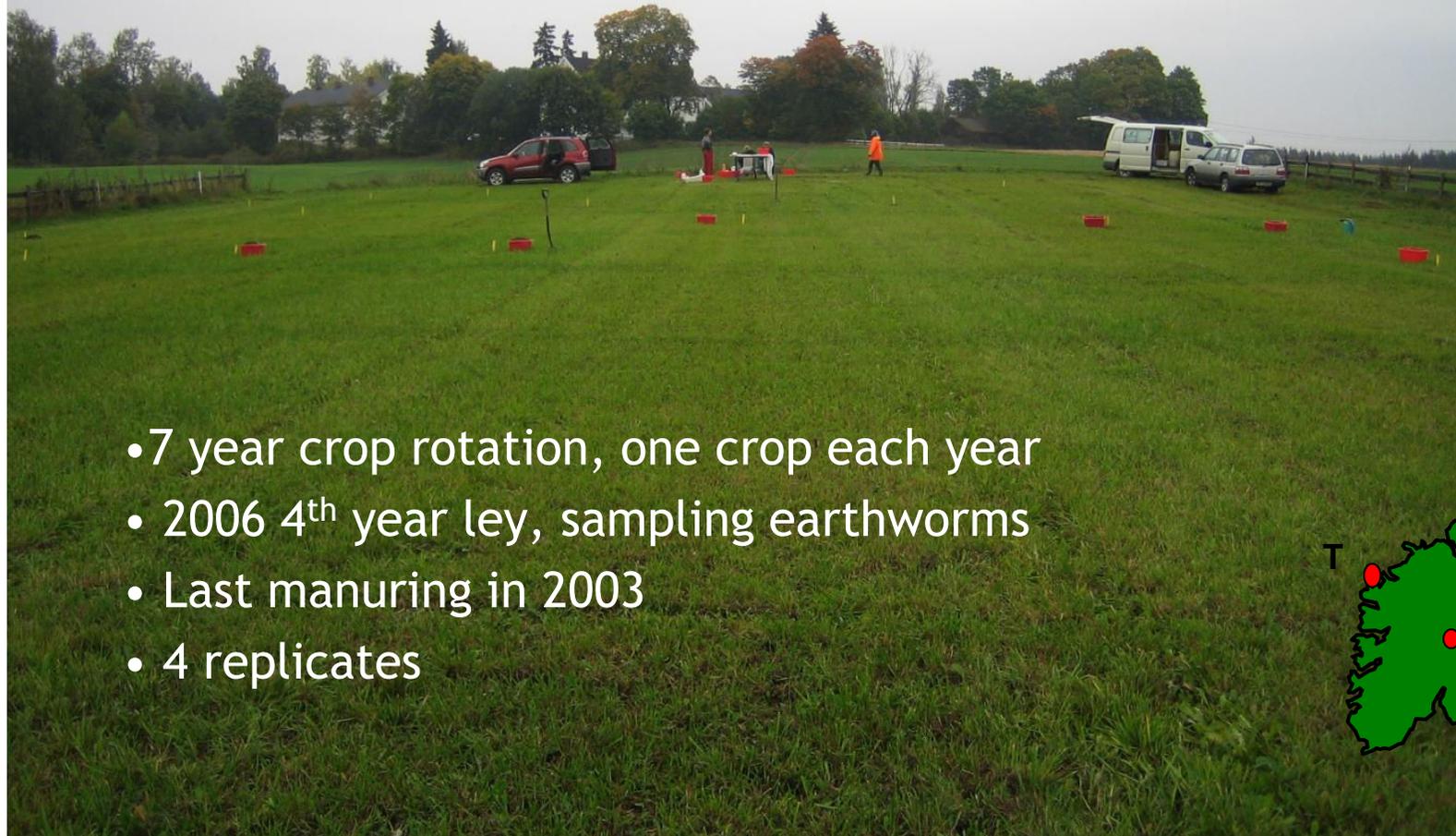
Biomass of earthworm



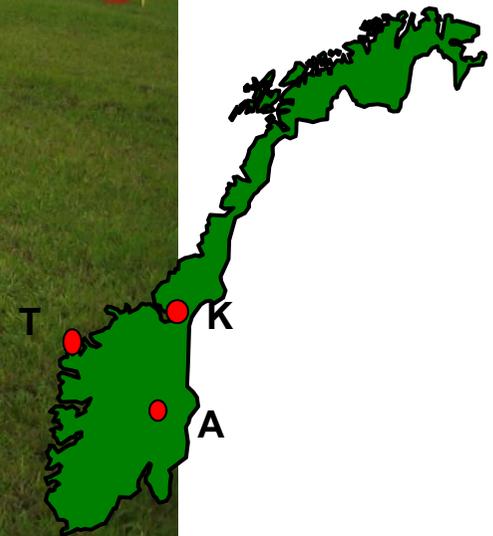
Results cropping systems

- Inclusion of leys in the crop rotation increased number of channels, earthworm number and their biomass.
- Organic arable had higher density and biomass than conventional
- Conventional fodder system had highest density, but no difference in biomass and channels

Møystad long-term fertilisation trials (A)



- 7 year crop rotation, one crop each year
- 2006 4th year ley, sampling earthworms
- Last manuring in 2003
- 4 replicates



Møystad Hårs eug. mark
fra 20 cm og nedover (30x30cm)
E8 E6 E7 E2
uten gj. 2t husdgi. 4t husdgi. NPK

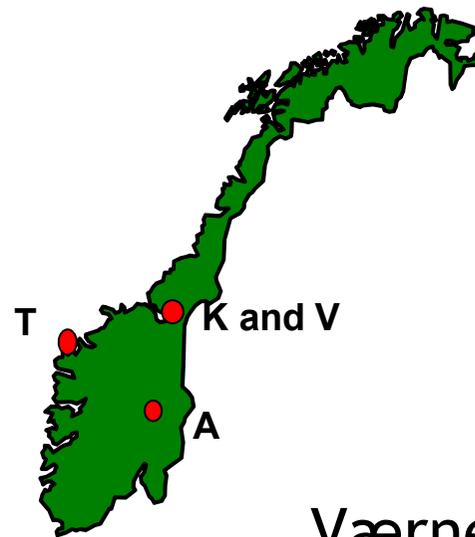


- Positive effect of solid animal manure, even 4 seasons after the last manuring.



Green manure management

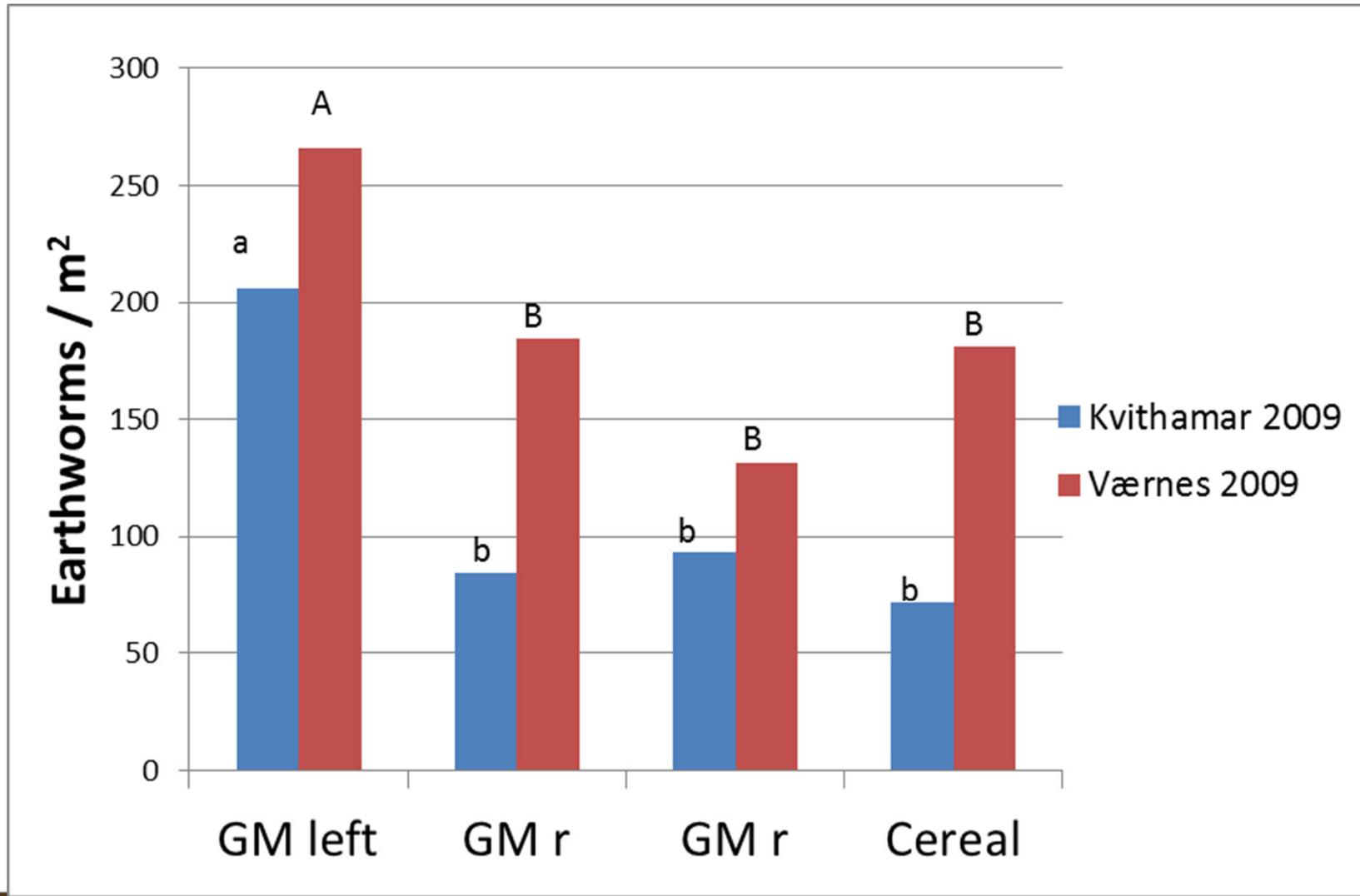
- Effects of different green manure management
- Sandy soil (V), clay soil (K)



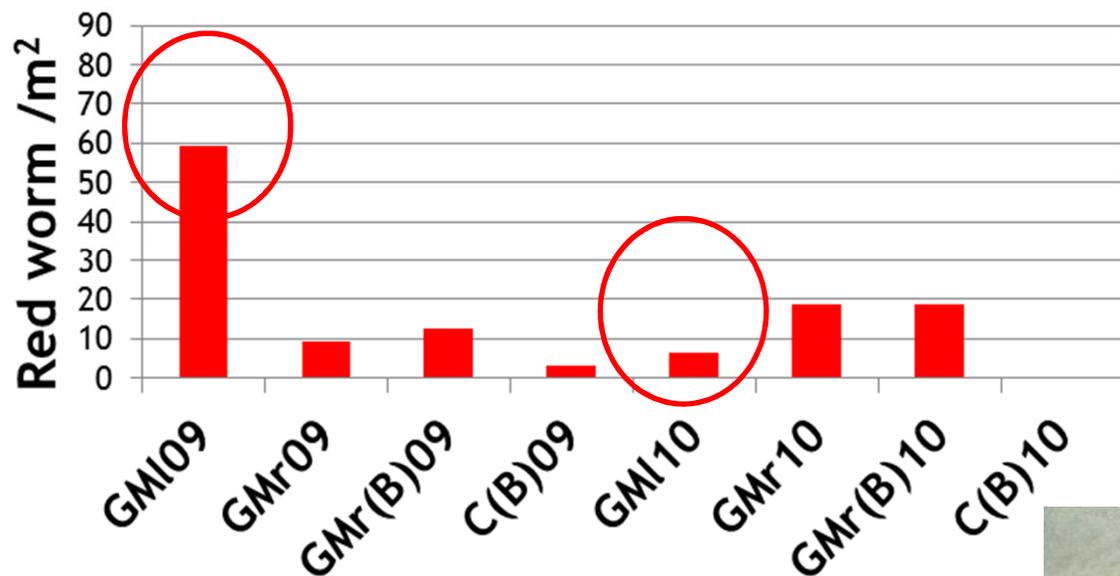
Værnes
aug 2009



Green manure management



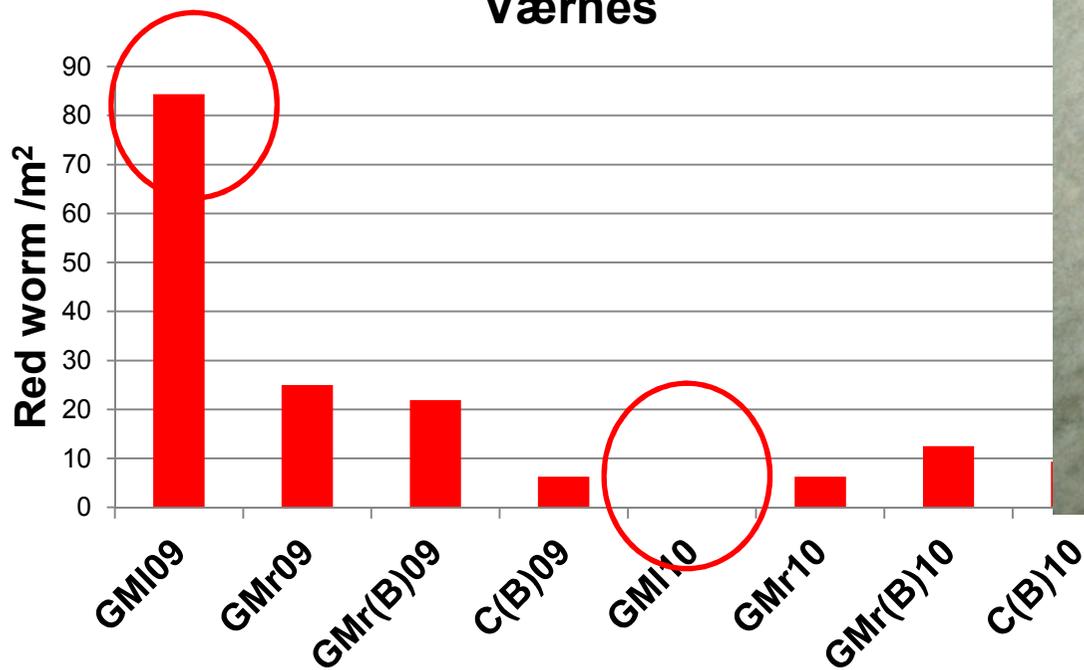
Kvithamar



K, clay soil

Red worm (*L. rubellus*),
living in the upper 5
cm of the soil

Værnes

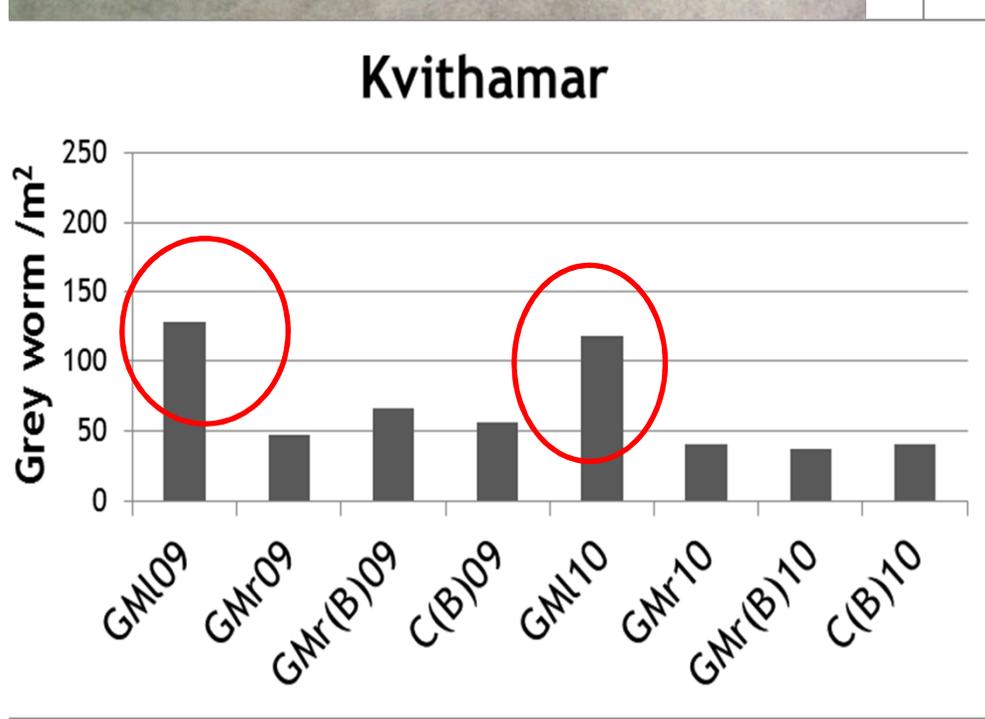


V, sandy soil

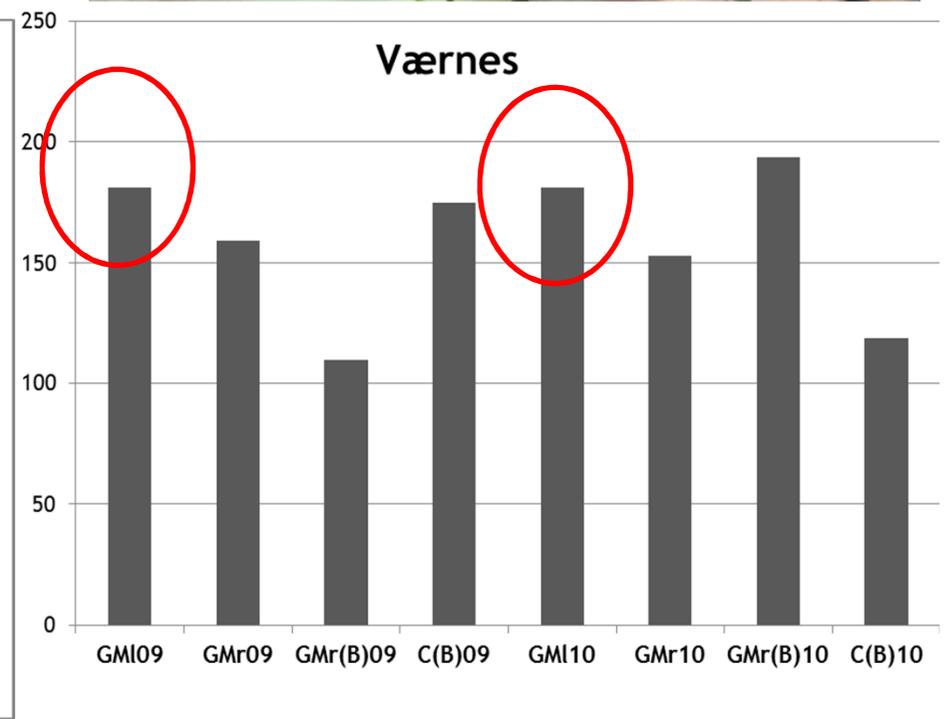




Soil living grey worms
(*A. caliginosa*)



Clay soil

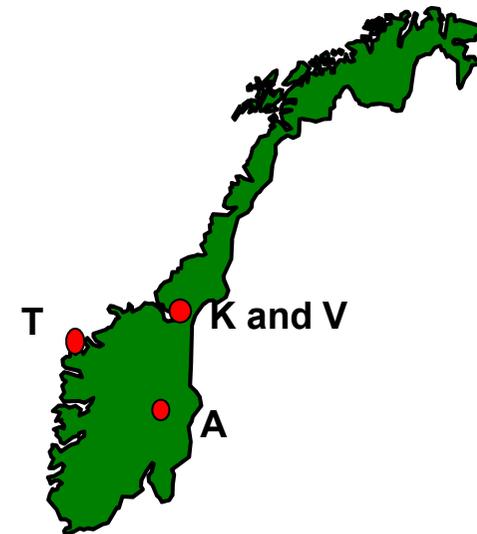


Sandy soil

Soil compaction and tillage, Bioforsk Kvithamar (K) og Apelsvoll (A)



- Plothing depth (15 vs 25 cm)
- Tractor weight (2-3 vs 5-7 tonnes)
- Driving pattern/compaction (3 times normal driving)
- Nutrient content in earthworm excrements (casts)



Results

- Earthworms were hardly affected
- Shallow ploughing (15 cm) was not destructive for the biomass and number of earthworms (grey worms)
- More worms when ploughing with a small tractor (5t) than with a heavier one (7t) at Apelsvoll (2006), no effects in the clay soil at Kvithamar

Lumbricus terrestris (dew worm) eats mostly plant residues, produces nutrient rich manure/cast. Not common in arable soils.



Nutrient content in geophagous earthworm casts in organic cereal production



Aporrectodea caliginosa eats mostly soil and dominates the fauna in arable soils.

How nutrient rich are their casts?





Earthworm casts on the soil surface.

How do we collect the casts from field worms that mostly are in the soil?



Litterbags from two soil types and soil depths

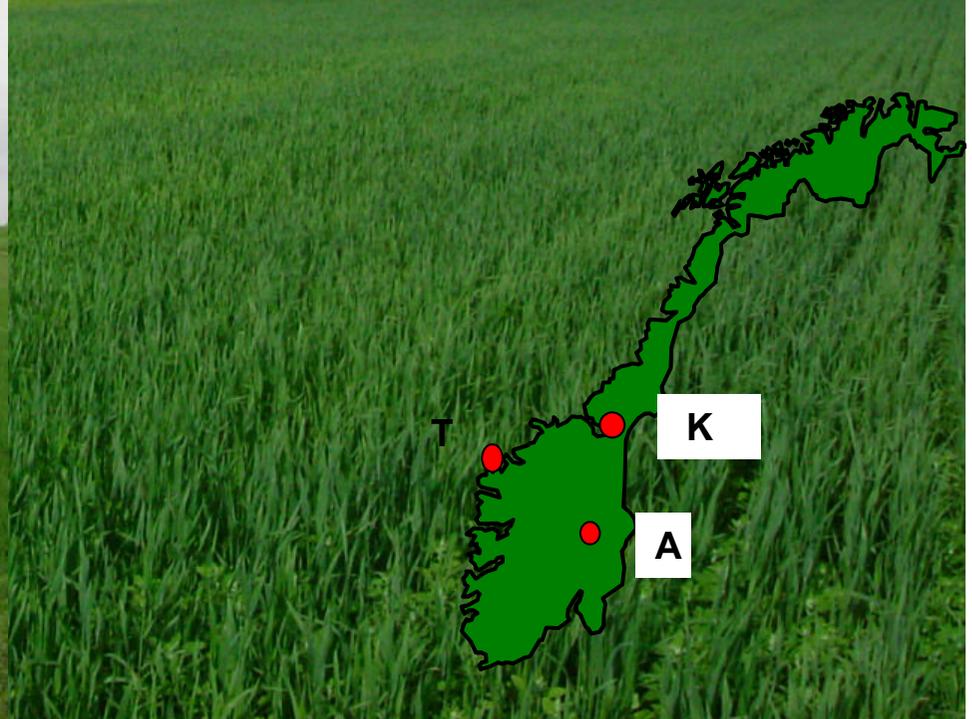
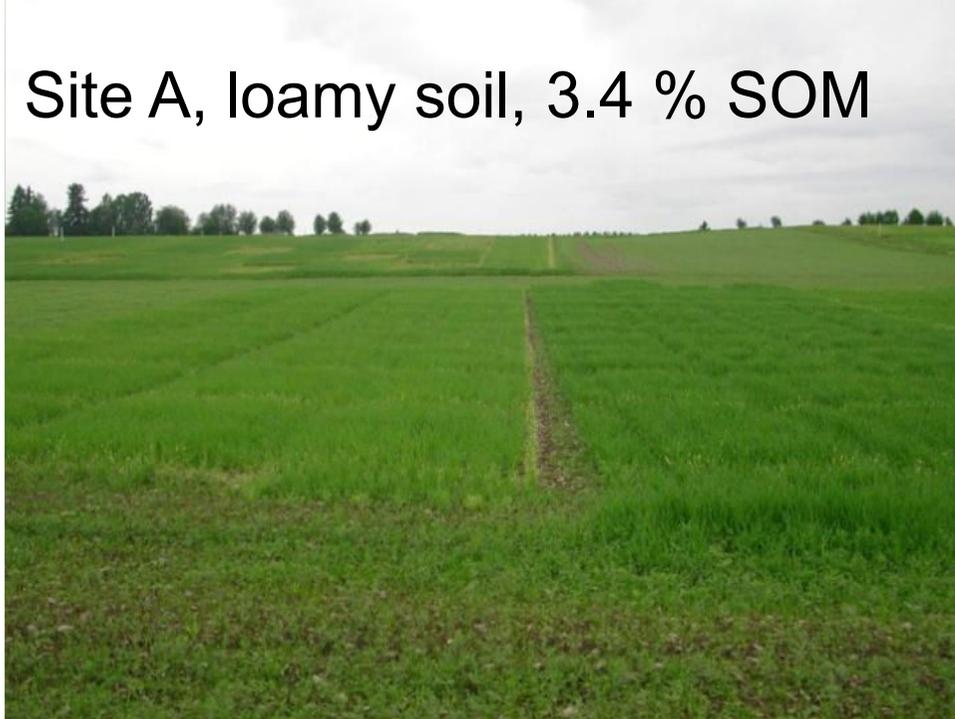
- 48 litterbags
- 13 cm and 25 cm
- May 25, 2005
- Bulk soil
- Litterbags up
Aug 23 and Oct 18



Site K, clay soil, 4.9 % SOM



Site A, loamy soil, 3.4 % SOM



Litterbags with barley straw taken up every third week



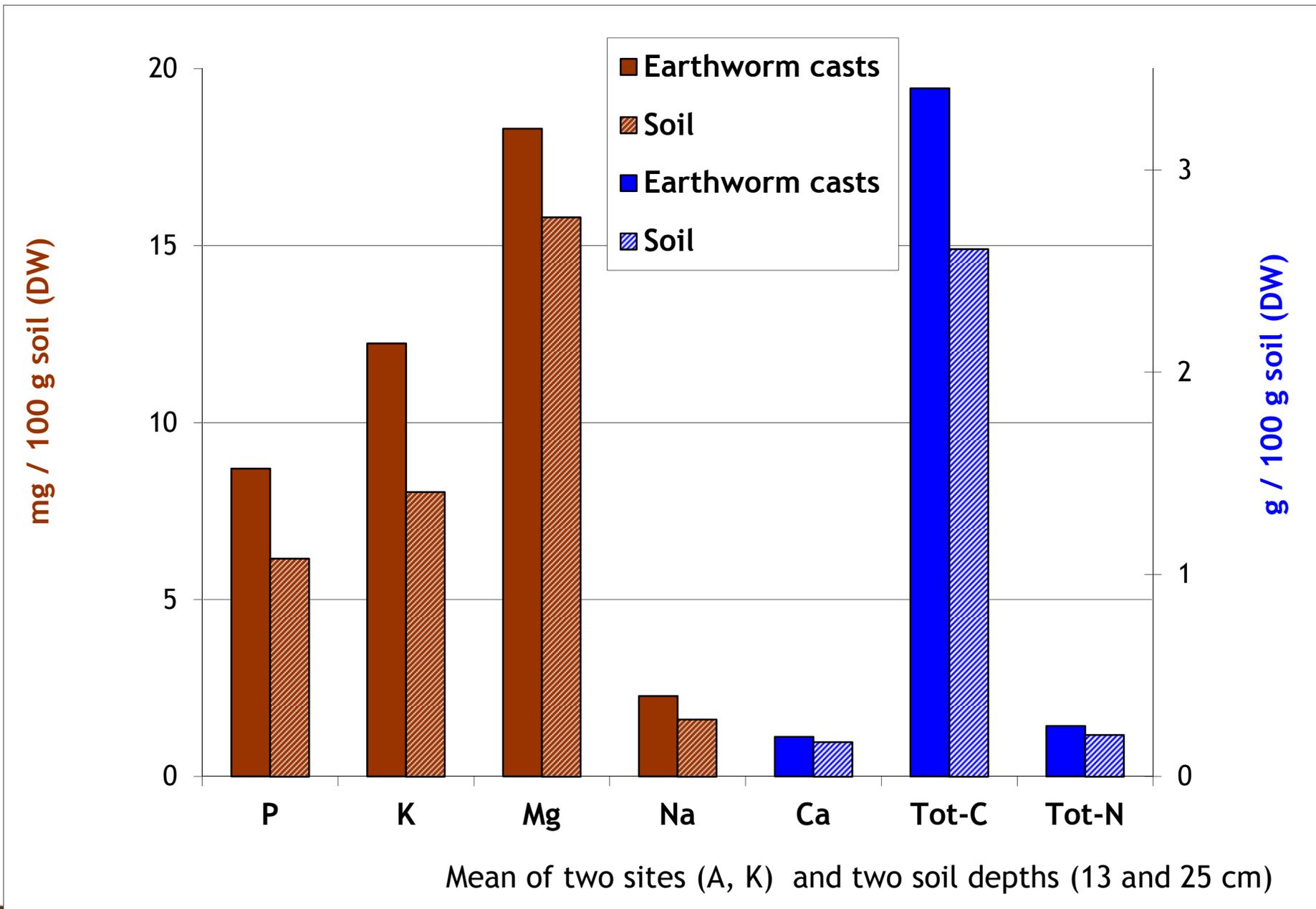
2



Casts and bulk soil

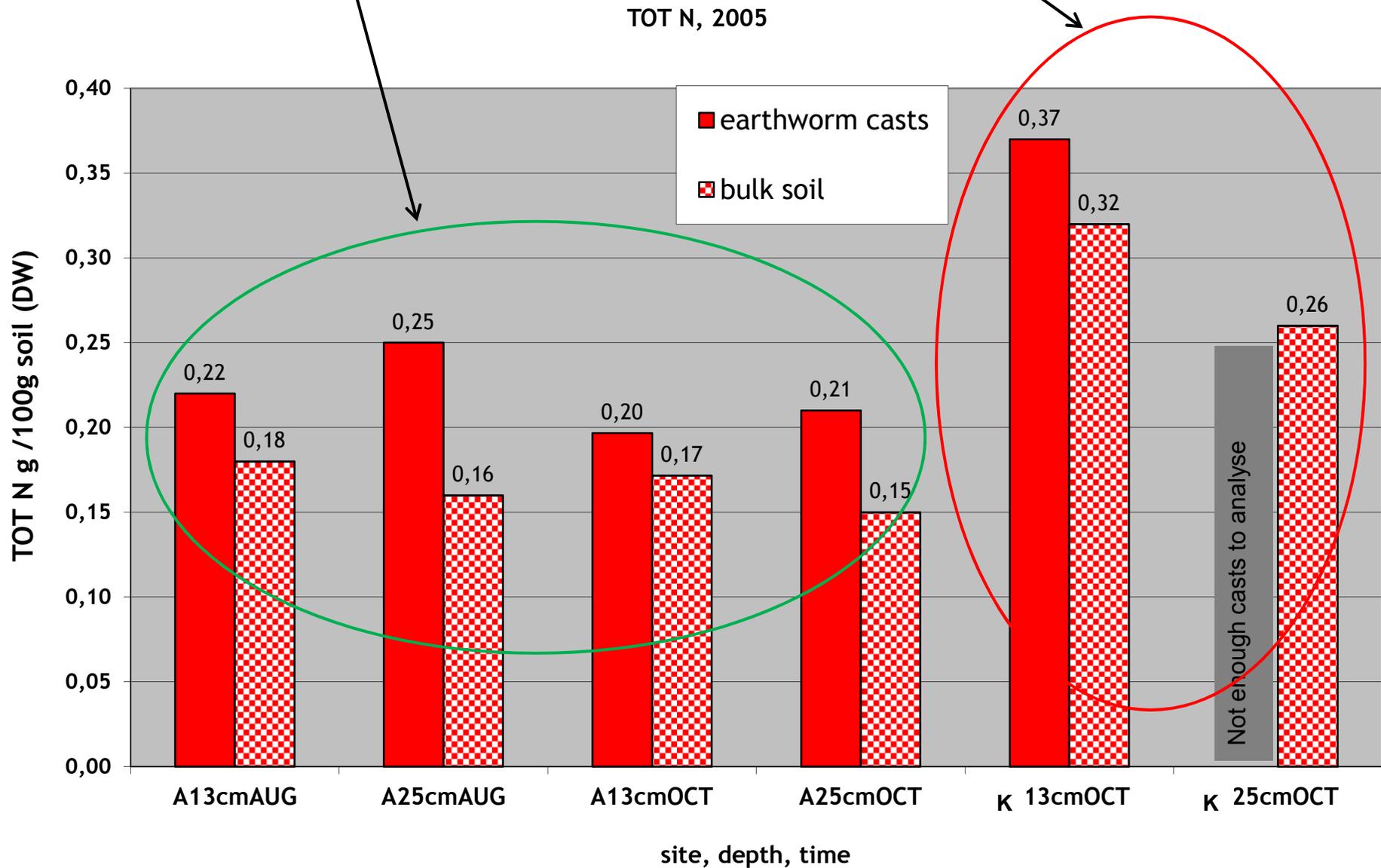
- Sorted out cast
- 0.5 - 6 g dry weight of casts
- Ammoniumacetat-lactate (AL)- extractable nutrients (P_{AL} , K_{AL} , Mg_{AL} , Na_{AL} , Ca_{AL})
- Tot -N and Tot-C



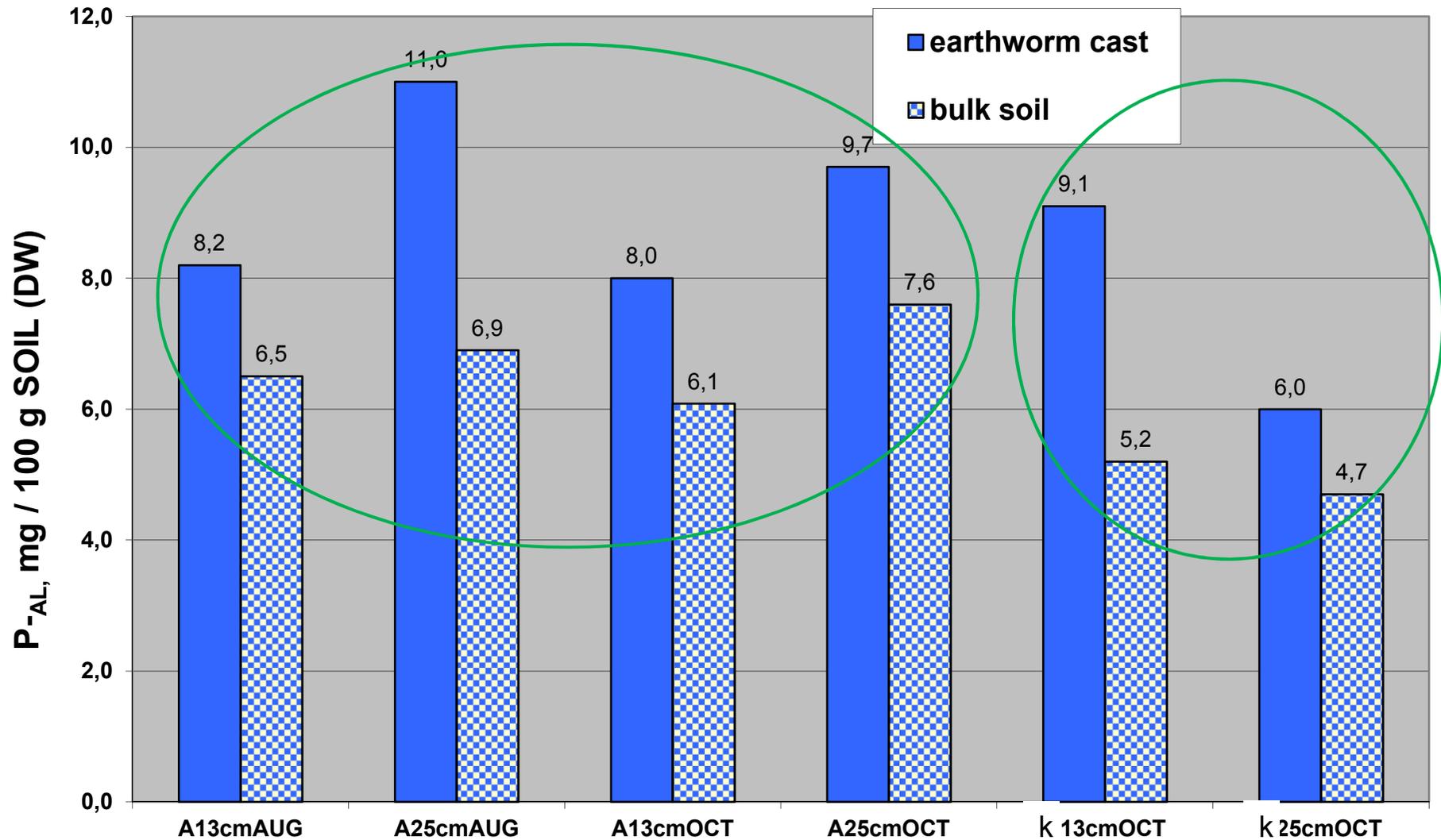


Mean of two sites (A, K) and two soil depths (13 and 25 cm)

- The content of tot-N was higher in clay soil (site K) than in loam (site A) = effect of soil type



No effect of soil type on P_{AL} , K_{AL} or Mg_{AL}



Dominance of soil eating earthworms

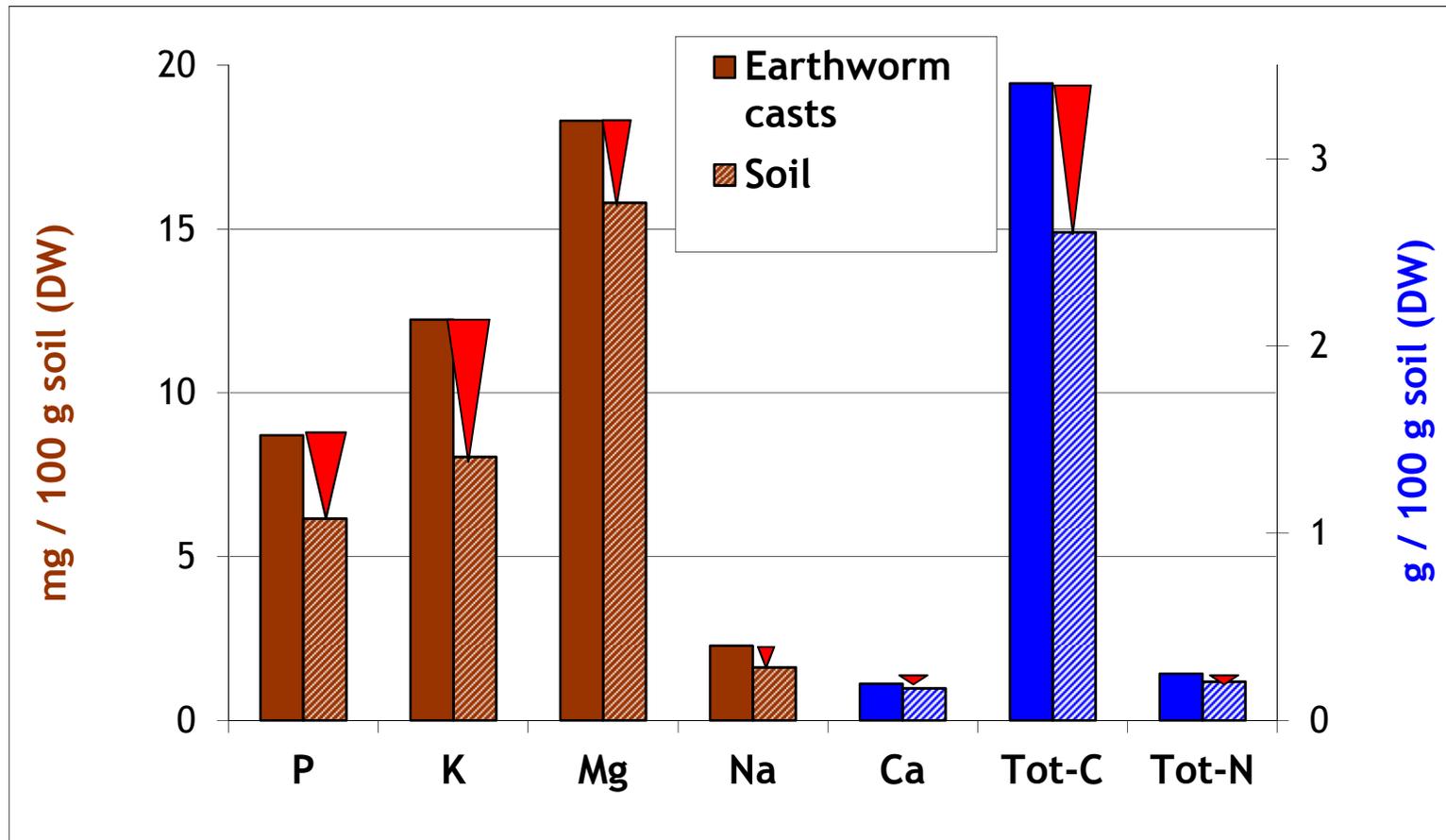
- 230 earthworms/m² (mean three years)
- 80 - 85 % (ind.) *A.caliginosa*, 5 -15 % *A. rosea*
- produce **220 000 kg casts/ha** and year (dry w)
(0.63 g/day, 153 active days/year, Boström 1988)
- 2 290 000 earthworms/ha



**220 t ~ the weight of
32 tractor a 7 tonnes**

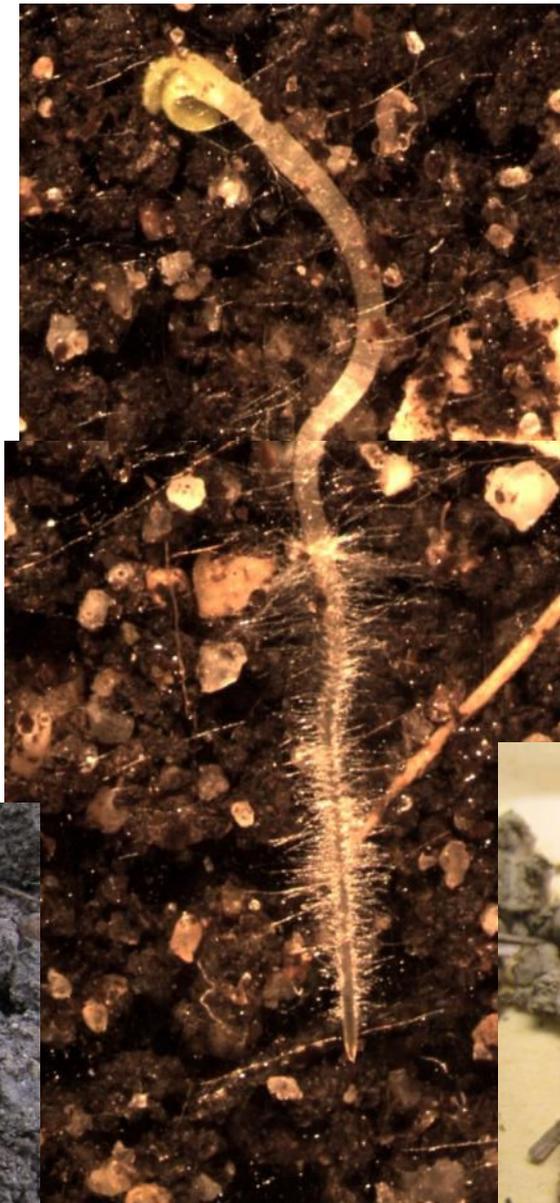


Nutrient enrichment ∇ =
 content in cast - content in bulk soil



Nutrient enrichment in cast (per ha and year)

- 5.6 kg P_{AL}
- 8.9 kg K_{AL}
- 5.3 kg Mg_{AL}
- 144 kg N (tot-N)
- 2542 kg C (tot- C)



Summing up - casts

- The content of “plant available” nutrients and tot-C and tot-N was higher in casts than in bulk soil
- No differences between soil depths (13 and 25 cm)
- Earthworm casts are valuable sources of plant nutrients
- How did the casts get more tot-N?
- Earthworm work through 220 tonnes soil/ha/y



Acknowledgements:



- Skilled and enthusiastic Bioforsk colleagues
- Funding: Research Council of Norway, The Agricultural Agreement Fund.



Earthworms inside and newly hatched from cocoons (Photo R. Pommeresche)