Effect of tillage on earthworms over short- and medium-term in conventional and organic farming

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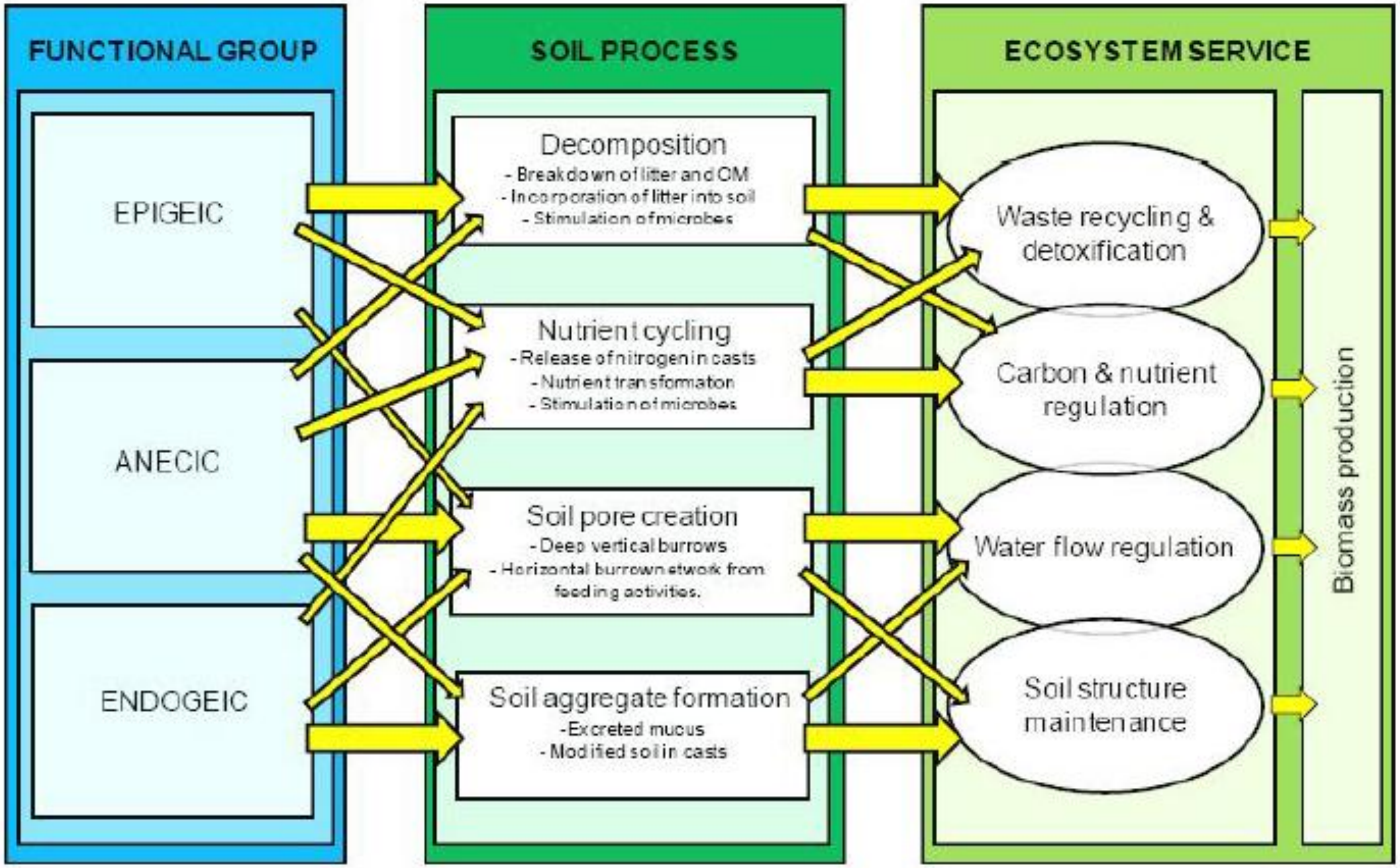
Earthworms play a role in soil functions



Keith and Robinson, Earthworms as Natural Capital: Ecosystem Service Providers in Agricultural Soils. Economology Journal, Vol. II Year II, January 2012

Soil compaction

Photo: Mirjam Pulleman

Dutch crop rotations including potatoes and sugar beets cause soil compaction

- Decreased physical functioning
- Impede crop growth
- GHG
- Soil biota, including earthworms

Reduce tillage to improve structure and function

Non-inversion tillage reduces tillage intensity but can still be used with tuber crops

Photo: Steve Crittenden

Objectives and hypotheses

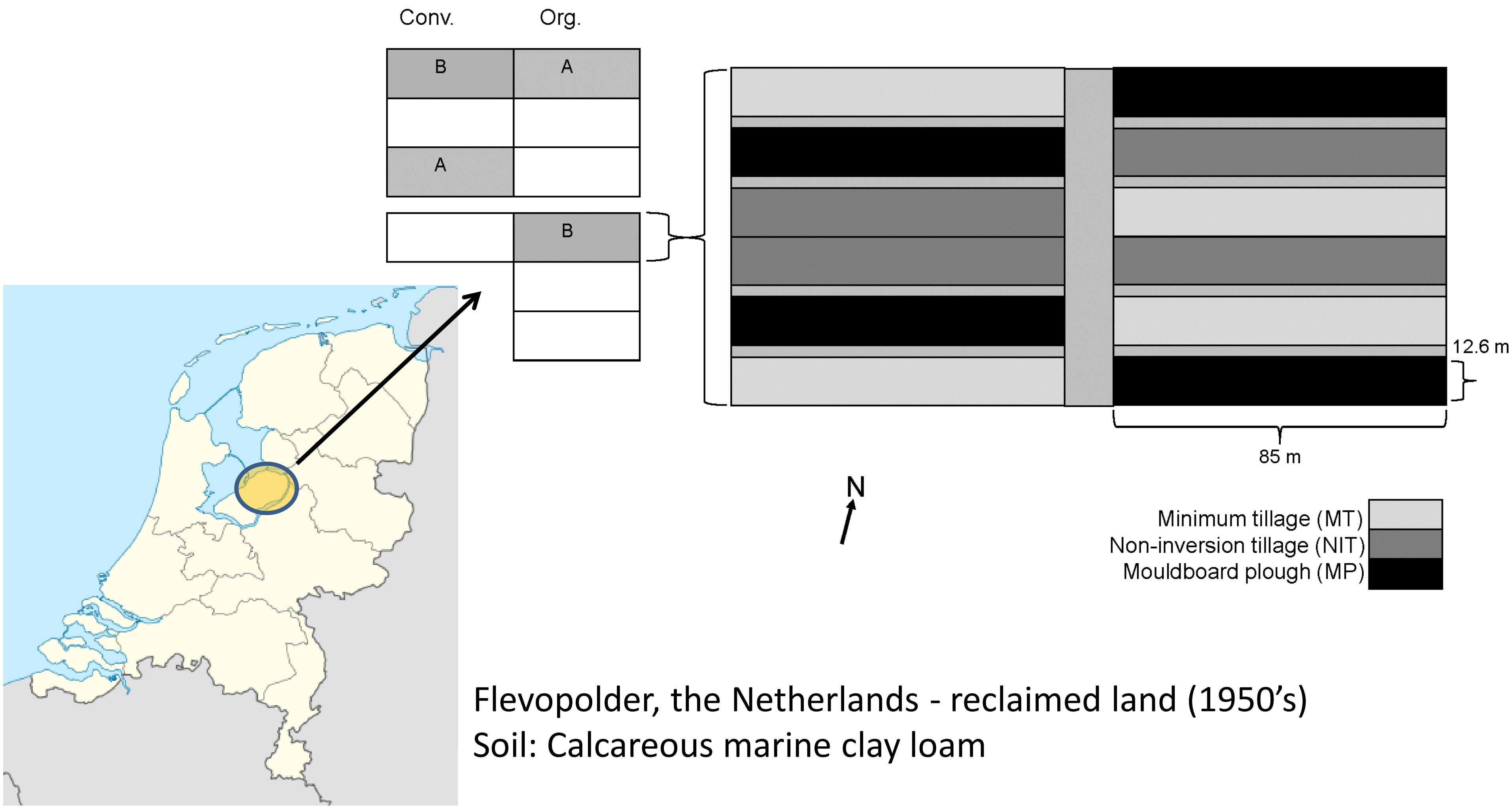
To quantify the effects of tillage systems on earthworm populations

- Mouldboard ploughing reduces earthworm populations immediately following ploughing and that this decrease would continue for several weeks.

- Medium term (4 years) reduced tillage intensity systems increase earthworm populations.

- Earthworm species abundances were expected to be positively correlated with soil organic matter content and soil moisture at the time of sampling but negatively correlated to soil compaction.

Site description, experimental design



Flevopolder, the Netherlands - reclaimed land (1950's)
Soil: Calcareous marine clay loam

Tillage treatments

Moulboard ploughing (MP)
25-30 cm in autumn +
superficial cultivation

Reduced tillage

Non-inversion tillage NIT
Subsoiling at ca. 20 cm in autumn and superficial cultivation

Minimum tillage MT
Superficial cultivation, subsoiling only when deemed necessary.

Earthworm change three ways

Short-term

Before ploughing → After 2 days → After 2 weeks → After 1 month

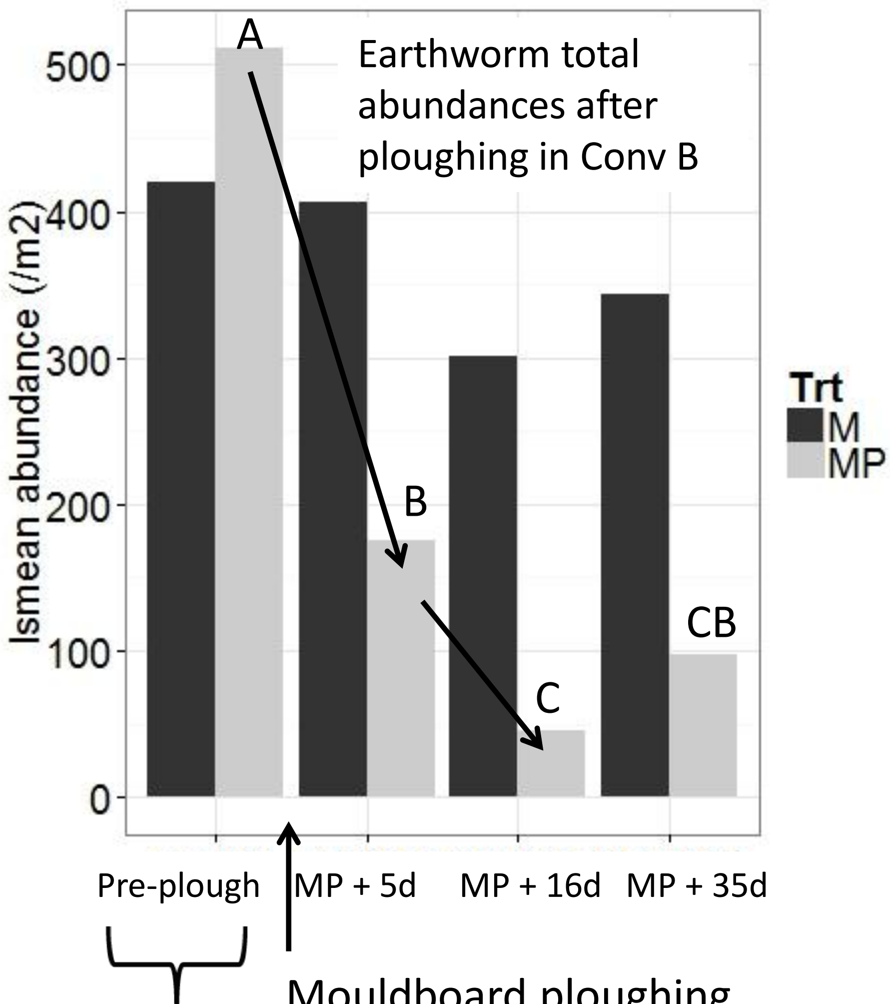
Medium-term

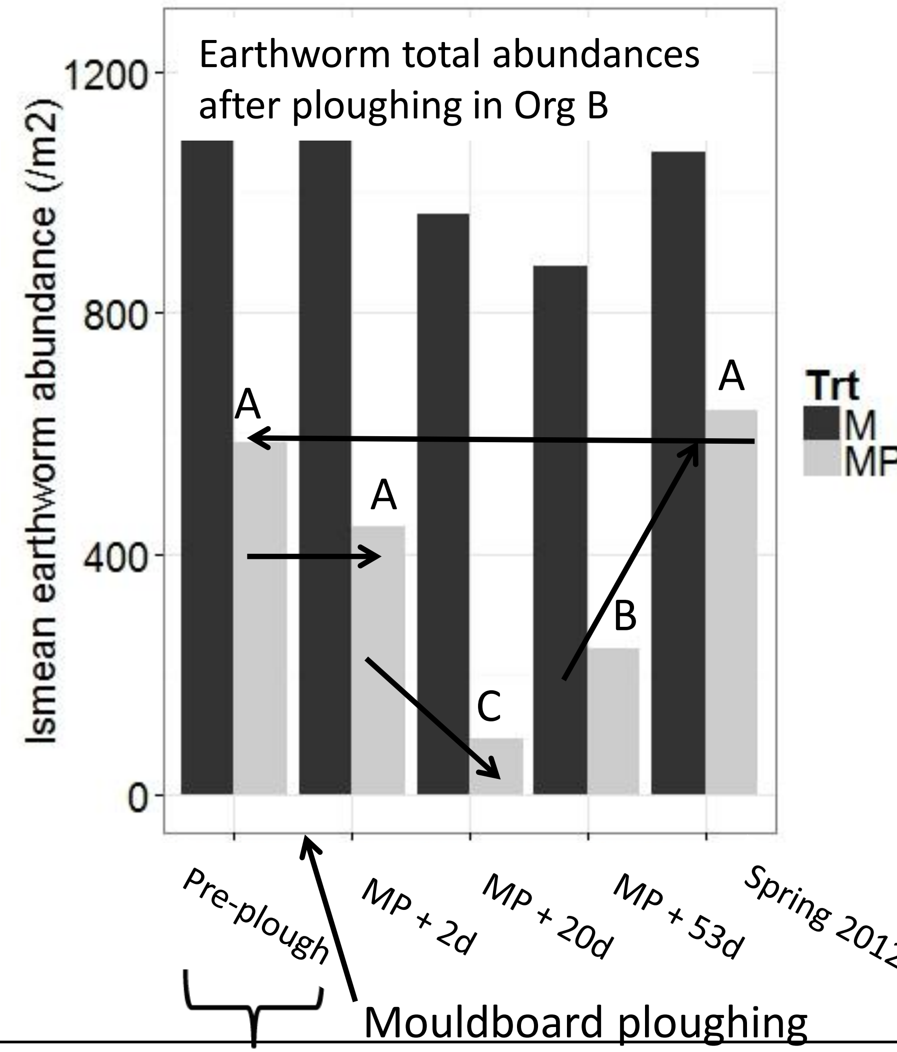
Spring 2009 → Fall 2009 → Fall 2010 → Spring 2011 → Fall 2011 → Spring 2012

(before fall ploughing)

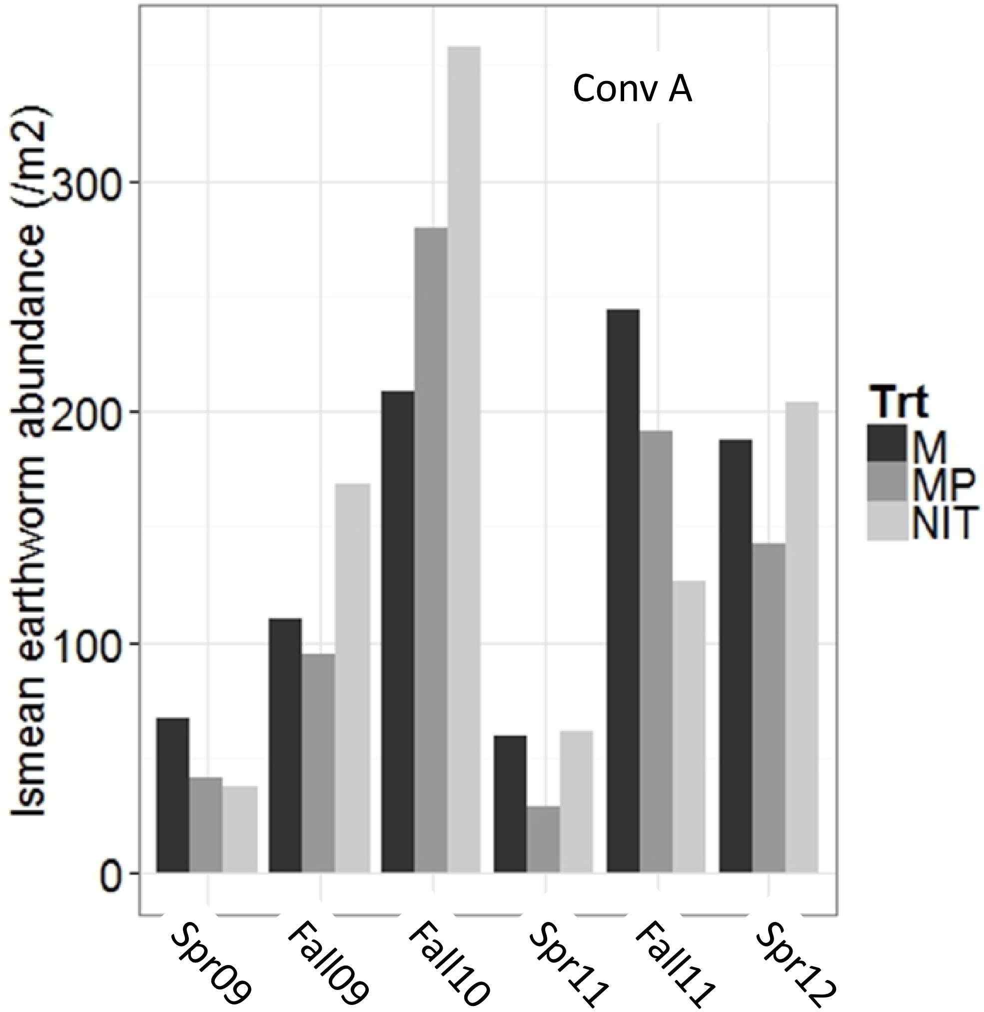
EARTHWORM /SOIL PROPERTY RELATIONS

Short-term effect of ploughing on earthworms





Medium-term effect of reduced tillage on earthworms

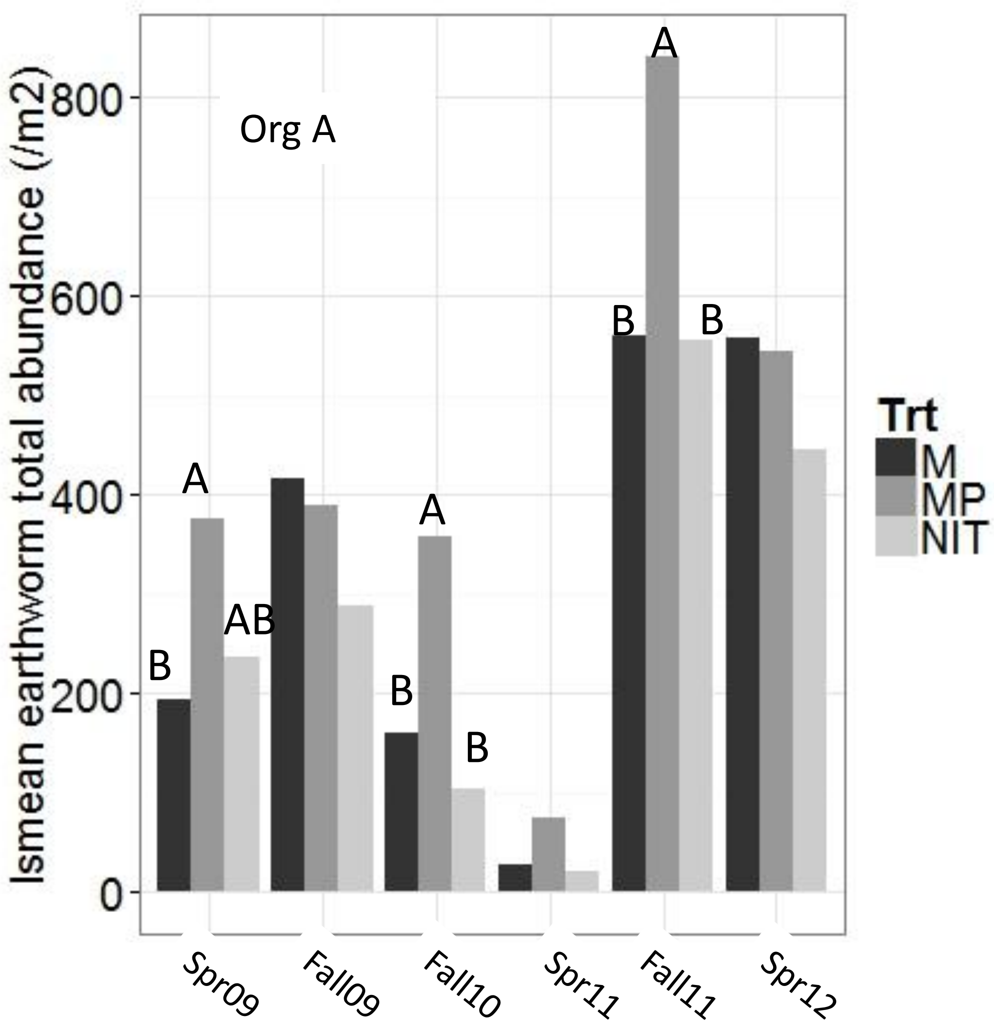


Medium-term: Earthworm abundances, Conv A

Sampling date	Tillage system	*A. caliginosa* (m−2)	*A. rosea* (m−2)	*L. rubellus* (m−2)	Total abundance (m−2)	Biomass (g m−2)	Adult/juvenile ratio
Spring 2009	MT NIT MP	50 26 40	7 2 1	1 2 0	68 38 41	- - -	1.01 b 2.37 a 0.30 b
Fall 2009	MT NIT MP	101 153 87	4 7 4	0 2 0	110 169 95	15 ab 26 a2 11 b	0.41 0.14 0.14
Fall 2010	MT NIT MP	170 b 277 a 240 ab	7 38 30	17 a 22 a 0 b	208 358 279	56 77 79	0.79 0.37 0.89
Spring 2011	MT NIT MP	49 52 23	3 2 3	2 0 0	60 61 29	12 a3 8 ab 3 b	0.63 0.50 0.25
Fall 2011	MT NIT MP	218 a 113 b 181 ab	2 3 10	12 a 0 b 0 b	245 127 192	44 a4 25 b 26 ab	0.48 0.49 0.16
Spring 2012	MT NIT MP	154 176 136	2 7 1	29 a 17 a 1 b	188 204 143	24 ab 35 a5 18 b	0.24 0.19 0.36

2 P=0.05, 3 P=0.05, 4 P=0.07, 5 P=0.07

Medium-term effect of reduced tillage on earthworms



Medium-term: Earthworm abundances, Org A

Sampling date	Tillage system	*A. caliginosa* (m−2)	*L. rubellus* (m−2)	*E. tetraedra* (m−2)	*A. rosea* (m−2)	Total abundance (m−2)	Biomass (g m−2)	Adult/juvenile ratio
Spring 2009	MT	125 b	45	6	8	195 b	-	0.41
	NIT	147 b	31	15	17	236 ab	-	0.26
	MP	273 a	45	21	5	375 a	-	0.42
Fall 2009	MT	227 b 2	168	0	9	415	129 a	0.46
	NIT	151 b	116	1	5	289	82 b	0.36
	MP	271 a	80	2	16	389	78 b	0.24
Fall 2010	MT	89 b	52	1	10	159 b	40 b	0.61
	NIT	64 b	15	1	5	104 b	34 b	0.57
	MP	271 a	44	7	23	357 a	75 a	0.35
Spring 2011	MT	18 ab	4	1	1	28	11	2.00
	NIT	8 b	5	1	1	21	6	0.25
	MP	58 a	2	1	2	75	16	1.22
Fall 2011	MT	365 b	50	21	10	560 b	97	0.38
	NIT	293 b	51	85	6	555 b	84	0.42
	MP	566 a	44	88	31	841 a	93	0.19
Spring 2012	MT	309 ab	84	20	12	557	74 a	0.50
	NIT	230 b	80	11	9	446	58 ab	0.51
	MP	383 a	38	8	5	543	35 b	0.26

2 P=0.07

Soil property data used in RDA

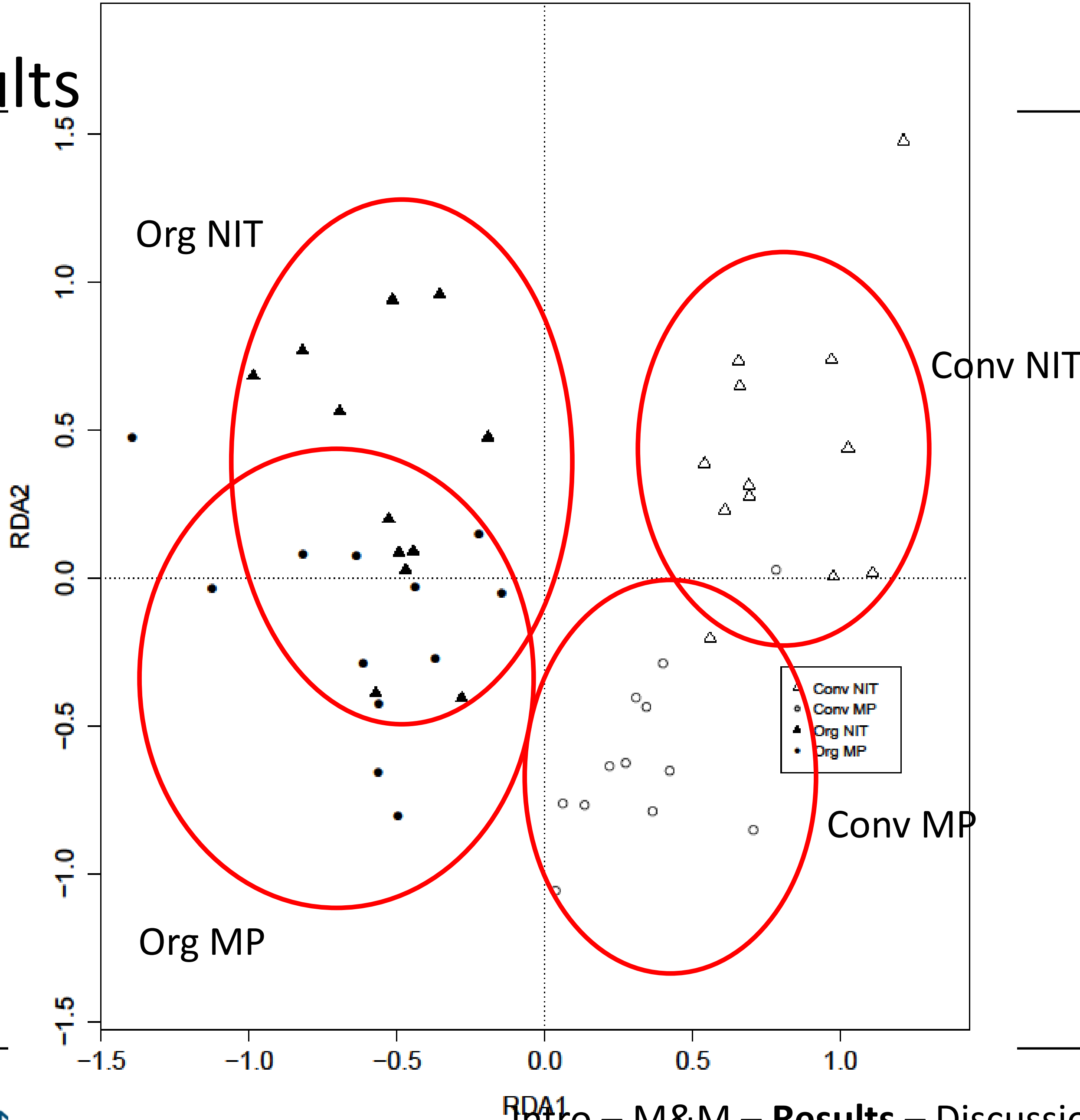
Farming system	Tillage system	Soil organic matter (g kg−1)	Soil moisture (g kg−1)	Penetration resistance (MPa) 0-5 (cm)	5-10 (cm)	10-15 (cm)	15-20 (cm)	20-25 (cm)	25-30 (cm)
Conv A	NIT	31.3 a	203 b	0.5	1.2 a	1.9 a	2.2 a	1.9 a	1.9 a
	MP	29.4 b	219 a	0.4	0.8 b	1.1 b	1.2 b	1.0 b	1.2 b
Org A	NIT	33.4 a	235	0.4	0.5	0.6 b	0.9	1.1	1.1
	MP	32.2 b 2	217	0.4	0.5	0.7 a 3	0.9	1.0	1.2

2 P=0.06
3 P=0.07

Loss on ignition

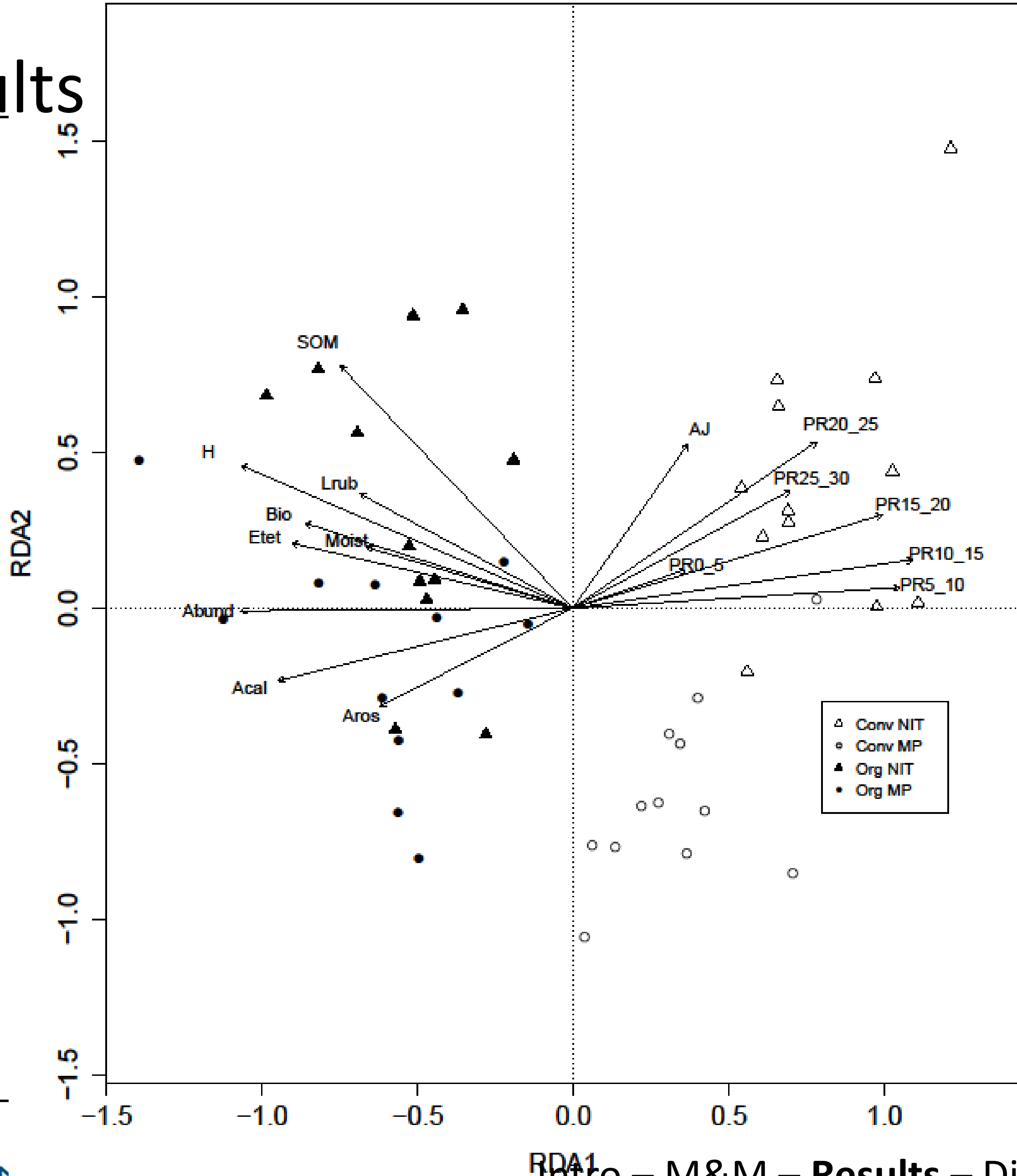
Penetrometer

RDA Results



Org NIT
Conv NIT
Conv MP
Org MP
Conv NIT
Conv MP
Org NIT
Org MP
RDA1
RDA2
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5

RDA Results



- Clear distinction between tillage systems and farming systems
- PR higher in Conv NIT, negatively correlated with EW
- Correlations of SOM and soil moisture with *L. rubellus* and *Eiseniella tetraedra*, but no correlation of SOM with *A. caliginosa* and *A. rosea*.

WAGENINGEN UR

Objectives and hypotheses

To quantify the effects of tillage systems on earthworm populations

- Mouldboard ploughing reduces earthworm populations immediately following ploughing and that this decrease would continue for several weeks. CONFIRMED

- Medium term (4 years) reduced tillage intensity systems increase earthworm populations. REJECTED – *Lumbricus rubellus* may be an exception

- Earthworm species abundances were expected to be positively correlated with soil organic matter content and soil moisture at the time of sampling but negatively correlated to soil compaction. PARTIALLY CONFIRMED

Conclusions

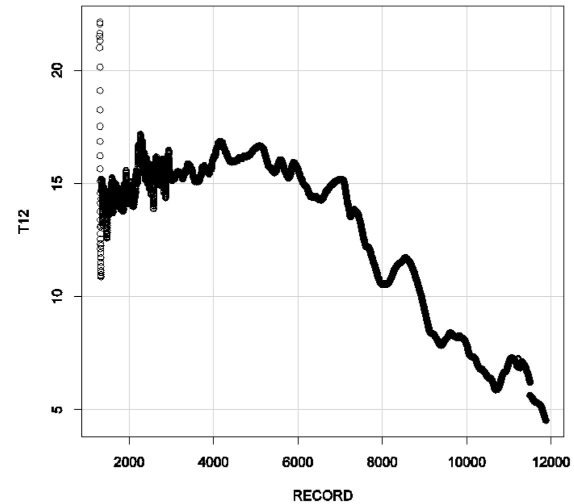
- In the short term, mouldboard ploughing (MP) negatively affected earthworm abundances (up to 53 days), however they recuperated to pre-ploughing levels by the following spring.
- Earthworm populations also recuperated in the medium-term study as shown by the general lack of negative MP effects on earthworm abundances.
- Total earthworm abundances in organic farming tended to be lower in reduced tillage than MP systems driven by the predominant species *Aporrectodea caliginosa*.
- Reduced tillage positively affected the epigeic *Lumbricus rubellus* in conventional farming.
- Interactions between tillage and organic matter management probably explain differing responses of earthworm ecological groups in the two farming systems.
- In general, organic farming had higher earthworm abundances, biomass and Shannon diversity than conventional farming.
- Variation between sampling dates was large, likely due to effects of crop and environmental conditions. Despite this variation consistent tillage system effects were observed.

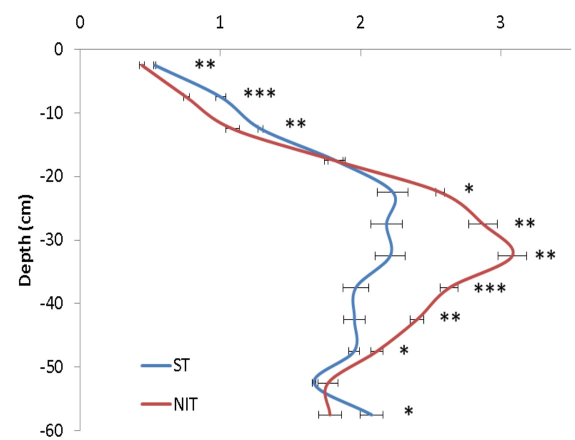
Crop yield in NIT

			NIT	yield ploughing (ton/ha)
2009	seed potato	Org B	101%	39.6
	carrot		79%	71.93
	spring wheat	Org A	108%	5.14
	sugar beet	Conv B	100%	93.7
	spring barley	Conv A	99%	9.2
2010	grass clover	Org B	108%	12
	faba bean/ spring wheat		83%	4.51
	carrot	Org A	84%	82.23
	winter wheat	Conv B	105%	11.4
2011	cabbage	Org B	95%	85.6
	potato	Conv A	95%	33.3
	faba bean/ spring wheat	Org A	110%	4.53
	onion	Conv A	91%	88.2
	seed potato		95%	34.4
2012	spring wheat	Org B	106%	5.57
	grass clover		139%	11.22
	potato	Org A	100%	20.16
	seed potato	Conv B	94%	37.6
	sugar beet	Conv A	103%	91.1

Soil Physical Quality – next analyses

	Org A	Conv A	Org B	Notes
Soil moisture /temperature	X	X		To be analayzed
Infiltration	X	X	X	Results variable
Aggregate stability	X	X	X	Mirjam will present
Water retention	X		X	No difference
SOC	X		X	No difference
Penetration resistance	X		X	Higher compaction in NIT





Questions?

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