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Using reduced tillage and green manures in organic systems – what is the research telling us?

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Outline

1. How do we study this? or what the heck is meta-analysis??
2. What is the data telling us about..reduced tillage (RT) in organic systems
3. Winter barley experience at Nafferton
4. Positives and negatives of reduced tillage
5. Take home messages

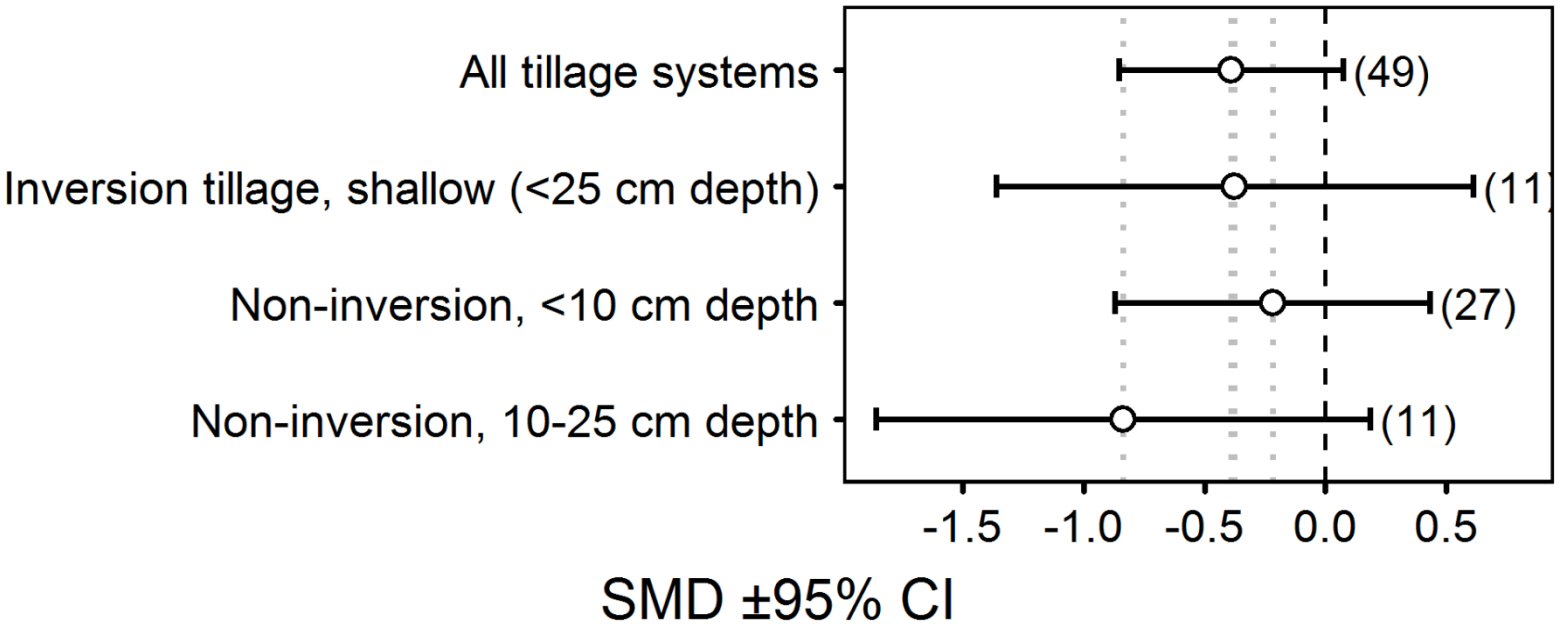
What is meta-analysis?

Meta-analysis refers to methods focused on contrasting and combining results from different studies, in the hope of identifying patterns among study results, sources of disagreement among those results, or other interesting relationships that may come to light in the context of multiple studies.

Wikipedia, from Greenland & Rourke, 2008

What is meta-analysis?

- **Many paired comparisons**
- **Always a "control" versus "other"**
- **e.g. conventional tillage versus reduced tillage systems**



Our approach

- Compile data from many sources
  - Peer reviewed
  - "Grey" literature
  - Ongoing field trials
- Criteria? Organic systems, using reduced tillage
- Extract data to a "database"

The essential treatments

Tillage	
Control	• Conventional tillage (annual ploughing, inversion, >25 cm depth)
Reduced tillage	• Inversion tillage, shallow (<25 cm depth) • Non-inversion, <10 cm depth • Non-inversion, 10-25 cm depth • *No tillage*

Further descriptors

Crop rotation

- arable with ley periods
- *horticulture with ley periods*
- intensive arable (no ley crops)
- *intensive horticulture (no ley crops)*

Irrigation

- *Irrigation only*
- None
- Primarily irrigated, some rain
- *Primarily rainfed, some irrigation*

Residue management

- exported
- buried
- mulch
- other

Mechanical weeding

- mechanical weeding 2-4 times
- mechanical weeding 5 or more times
- *mechanical weeding once*
- none

Further descriptors

Fertiliser source

- Zero fertilizer (no organic or NPK fertilizers or green manure)
- Farmyard manure or composted manure
- Fresh manure (including slurry)
- Farmyard manure or composted manure
- Green manure only
- Mixture FYM + slurry
- NPK

Fertiliser rate

- High (>200 kg N/ha/yr)
- Moderate (100-200 kg N/ha/yr)
- Low (<100 kg N/ha/yr)
- Zero fertilizer

Herbicide use

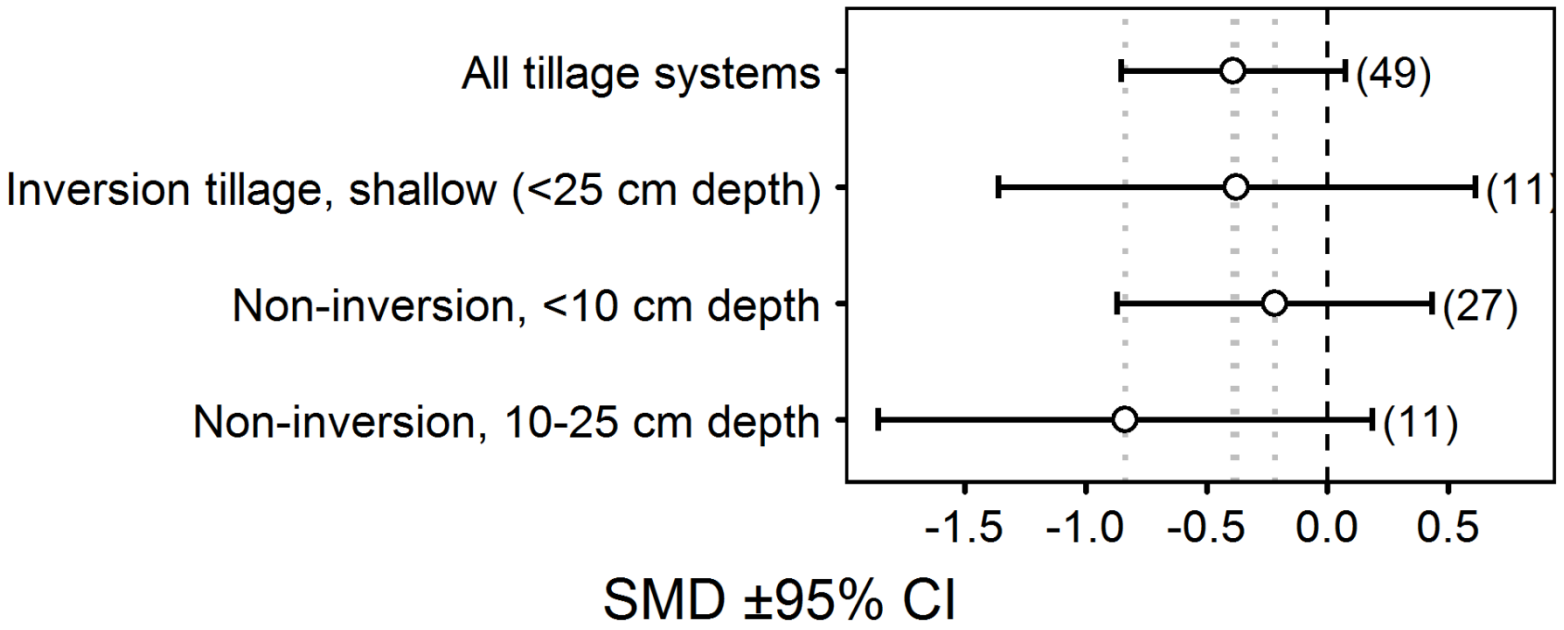
- *glyphosate only*
- *glyphosate, pre- & post-emergence*
- none
- *post-emergent & glyphosate*
- *post-emergent only*
- *pre- & post-emergent*
- *pre-emergent & glyphosate*
- *pre-emergent only*

What was measured?

Response list	# experiments	# datapoints
Aggregate stability (%)	*0*	*0*
Ammonium (mg/kg)	2	11
Carbon dioxide (CO2) emissions (g/m2/yr)	*0*	*0*
Crop yield - above-ground biomass yield - dry yield (t/ha)	6	152
Crop yield - marketable yield - combinable crops (t/ha)	7	98
Crop yield - marketable yield - non-combinable crops (t/ha)	4	47
Determination of soil pH (-)	5	42
Maximum water holding capacity (%)	*0*	*0*
Methane (CH4) emissions (g/m2/yr)	*0*	*0*
Nitrate (mg/kg)	2	25
Nitrous oxide (N2O) emissions (g/m2/yr)	*0*	*0*
Plant population density - annual crops (plants/ha)	4	82
Plant tissue N content - above-ground biomass - N uptake (kgN/ha)	2	96
Plant tissue N content - marketable product - N uptake (kgN/ha)	1	36
Plant tissue N content - marketable product (%)	1	7
Potential denitrification (nmol N2O/g/h)	*0*	*0*
Potential nitrification (ng NO2N/g/h)	*0*	*0*
Soil carbon stocks (%)	3	88
Soil carbon stocks (g/m2)	3	46
Soil microbial biomass carbon (ug/g)	2	24
Soil microbial biomass nitrogen (ug/g)	1	16
Soil nitrogen stocks (g/m2)	3	46
Substrate induced respiration (SIR) (ml CO2/g/h)	*0*	*0*
Weed biomass (annual dicots) (g/m2)	1	2
Weed biomass (annual monocots/grasses) (g/m2)	1	2
Weed biomass (perennial dicots) (g/m2)	*0*	*0*
Weed biomass (perennial monocots/grasses) (g/m2)	*0*	*0*
Weed cover (annual dicots) (%)	3	34
Weed cover (annual monocots/grasses) (%)	1	10
Weed cover (perennial dicots) (%)	2	16
Weed cover (perennial monocots/grasses) (%)	1	10
Weed density (annual dicots) (weeds/m2)	2	18
Weed density (annual monocots/grasses) (weeds/m2)	2	18
Weed density (perennial dicots) (weeds/m2)	2	24
Weed density (perennial monocots/grasses) (weeds/m2)	1	16

Effects of reduced tillage on marketable yield in organic systems

Marketable yield – effects of type of reduced tillage



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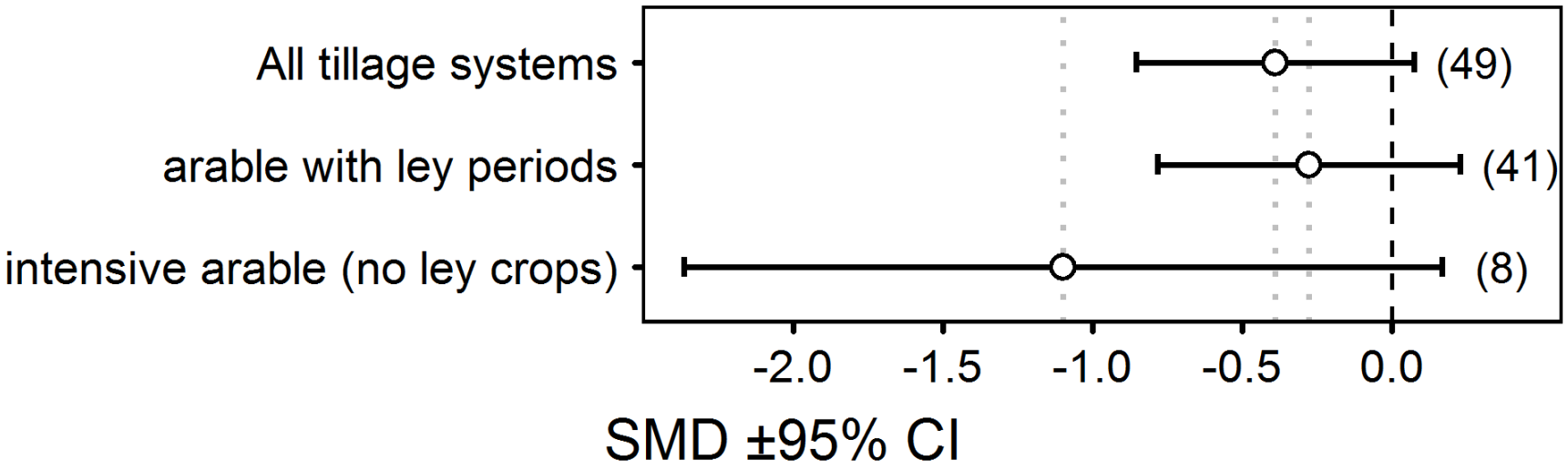
Marketable yield – reduced tillage effect in different crop rotations



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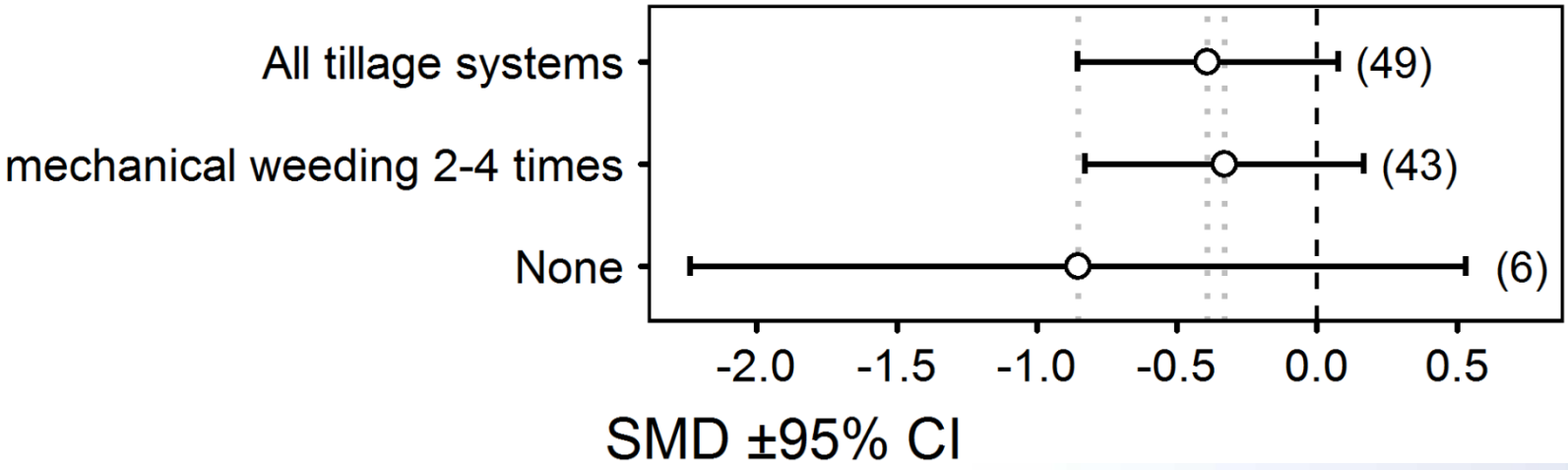
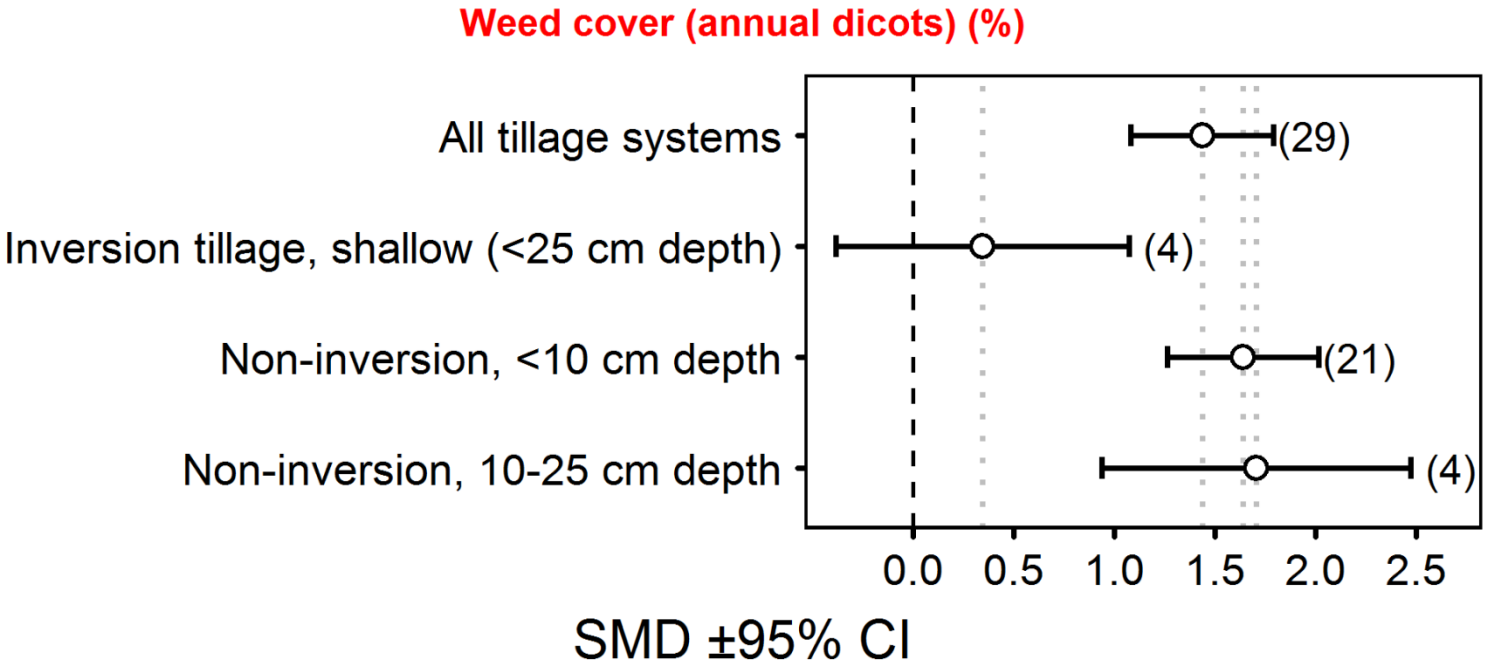
Marketable yield – reduced tillage effect using different weeding frequencies



Causes of yield reductions under reduced tillage
Could it be weeds...?

What does the data say about weed cover in organic systems under reduced tillage?



Trend towards more weed cover as tillage intensity decreases

Experiences from Nafferton Farm min till trials 2012

- Winter barley following winter wheat
- Factorial trial looking at:
  - Fertility management (ORG vs CON)
  - Crop protection (ORG vs CON)
  - Tillage (min till vs conventional till)
- Weeds monitored on 5 dates

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Effect of tillage and crop protection on weed cover (regardless of fertility management)
May 2012

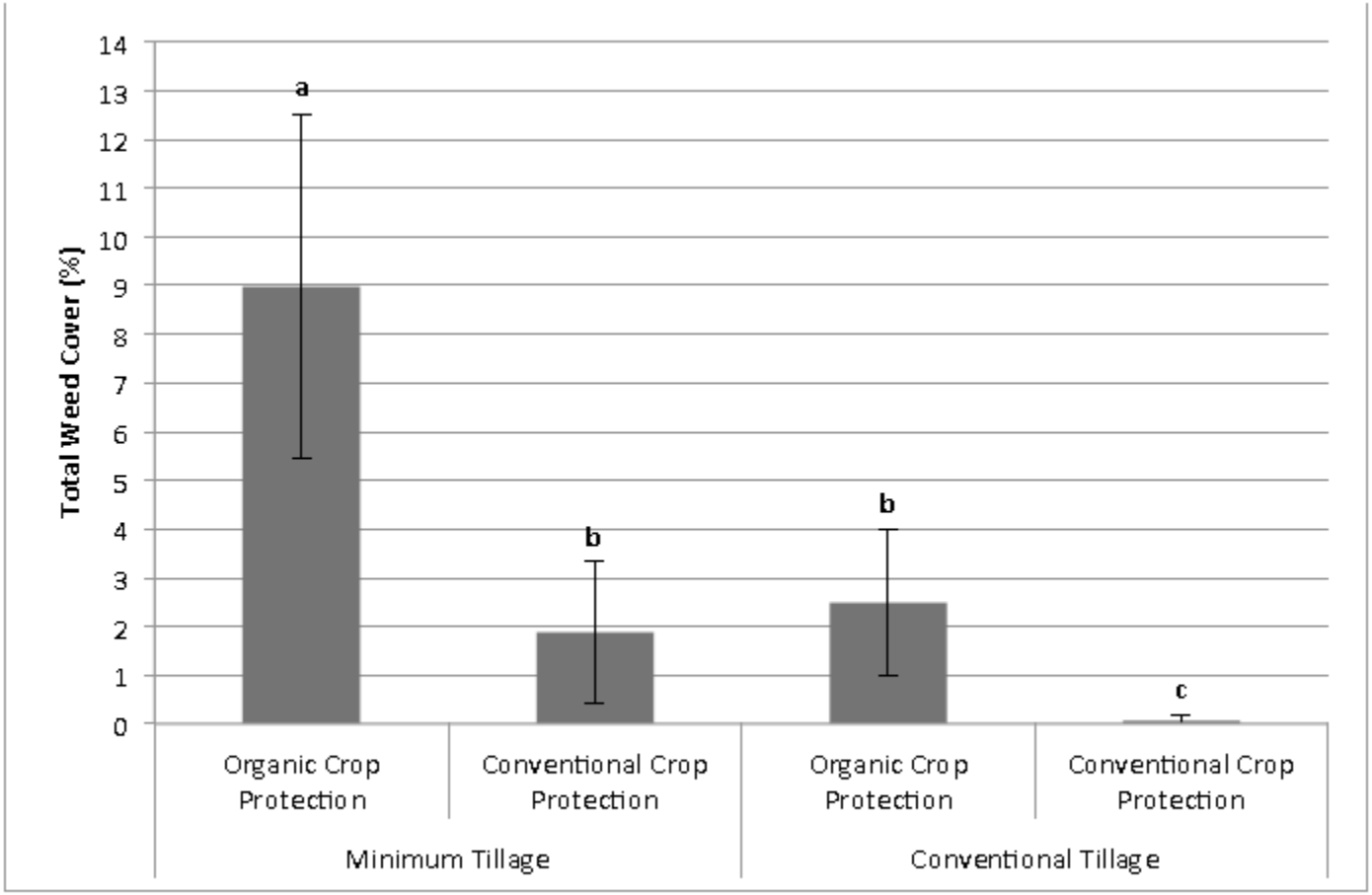

Figure 10. Effects of tillage and crop protection on total weed cover. Bars labelled with the same letter are not significantly different (Tukey's honestly significant difference test, $P<0.05$).

Chowdry, 2012, MSc dissertation

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Weed cover with minimum till under organic management (May 2012)

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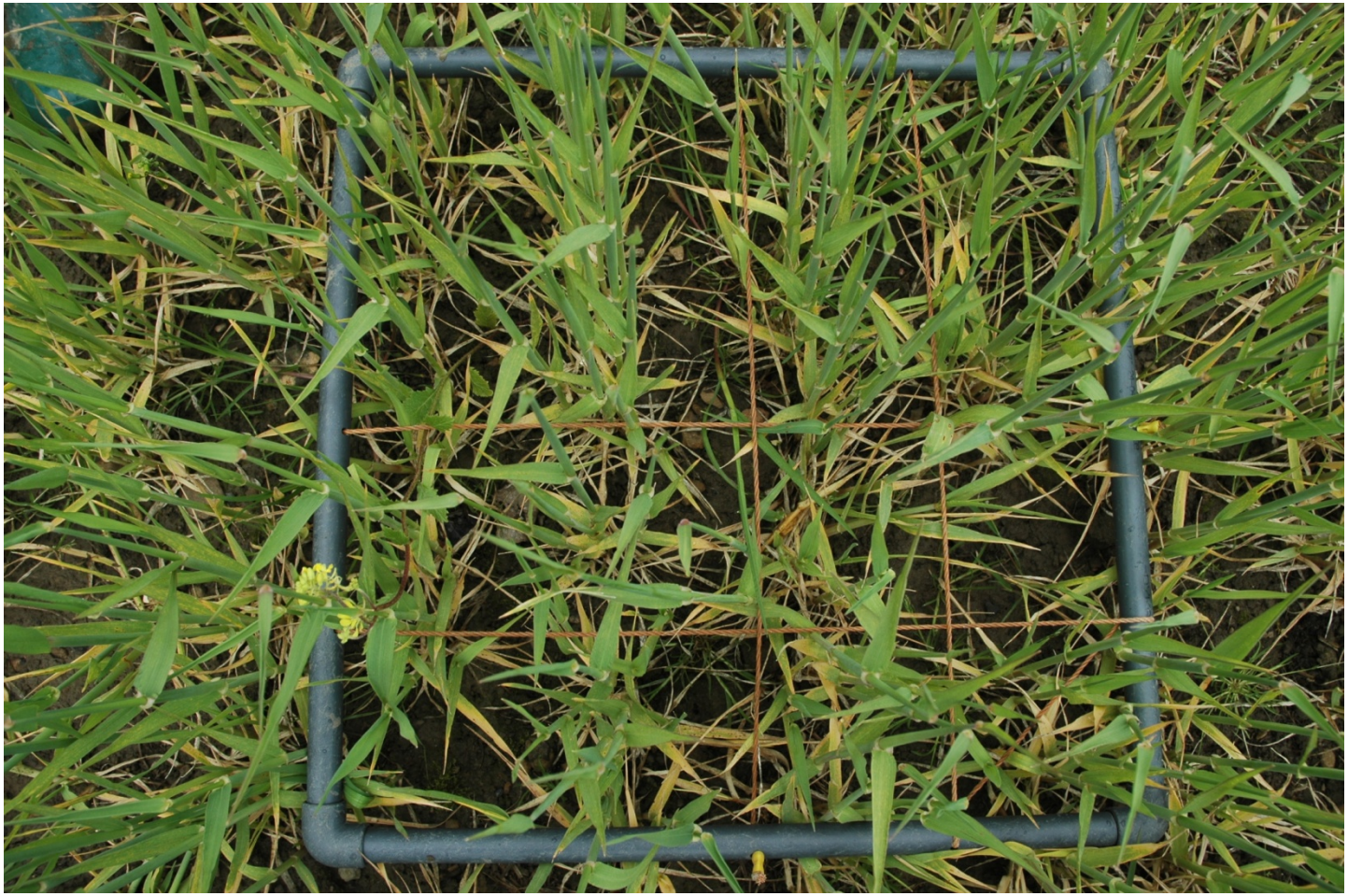
Chowdry, 2012, MSc dissertation

Weed cover with conventional till under organic management (May 2012)



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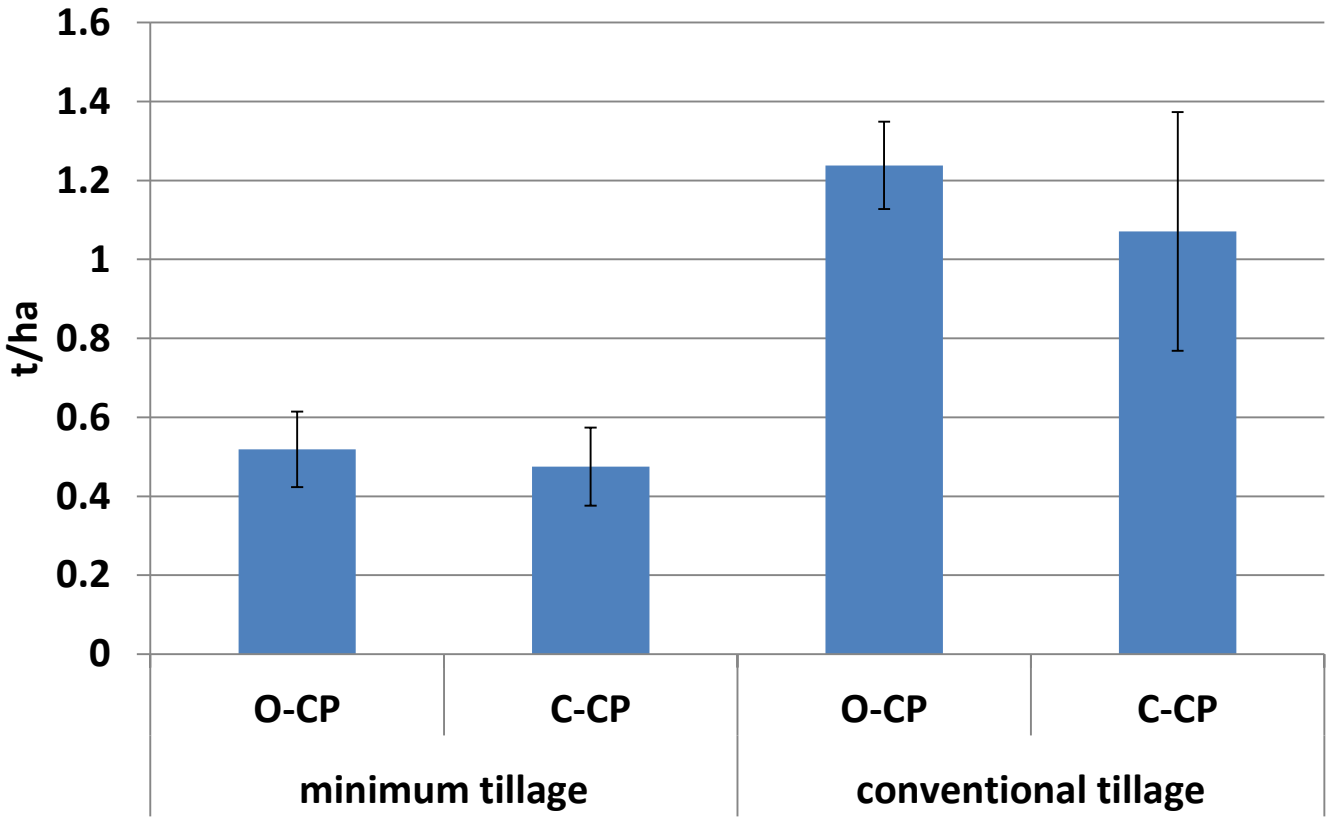
Chowdry, 2012, MSc dissertation

Winter barley yields under min till and conventional till (compost N source)



Factors affecting yield in min till systems

Negative effect

- Weed pressure
- Soil structure?
  - Possibly higher resistance to penetration, compaction and less root growth e.g. Vakali et al. 2011; Vian et al. 2009
  - Generally when two extremes are compared
  - Intermediate systems this is less evident

Factors affecting yield in min till systems

Negative effect

- Weed pressure
- Soil structure?
- Inhibited N mineralisation (especially in spring)

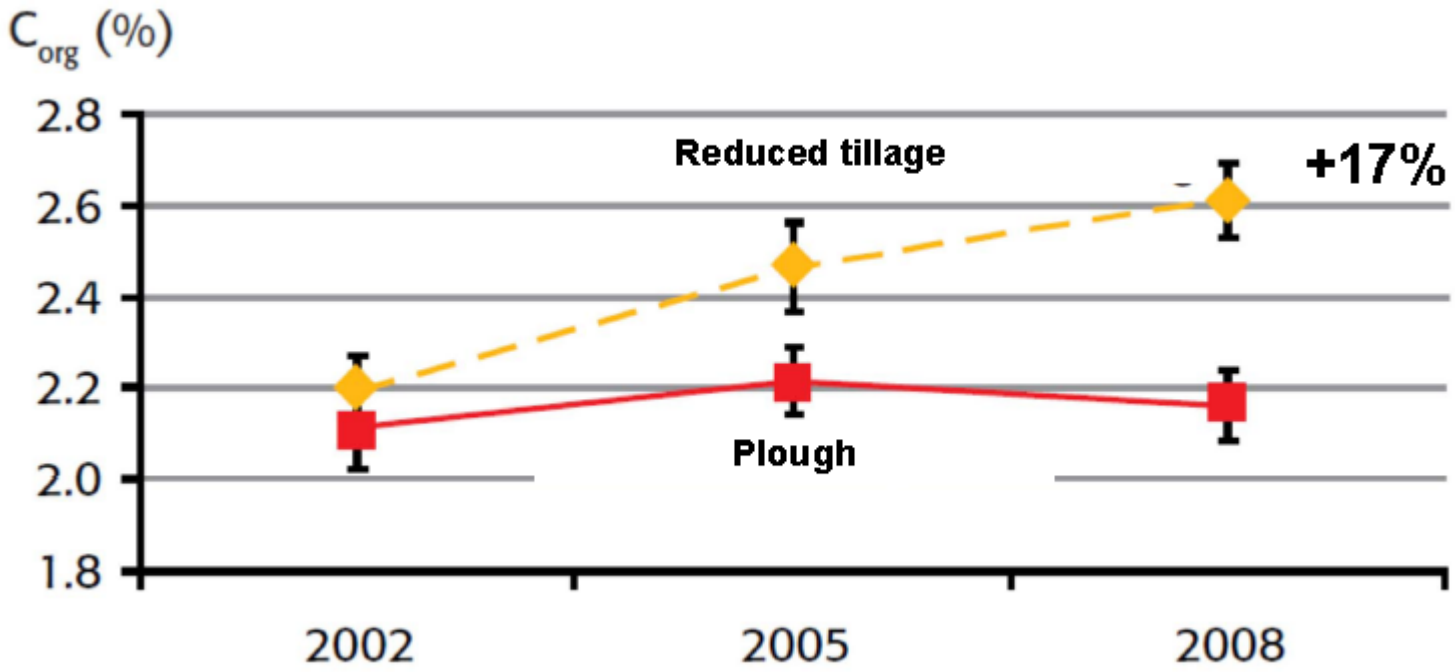
Min till + compost

Conv till + compost

Factors affecting yield in min till systems

Positive effects

- Increased carbon in surface soil



- Microbial biomass C and activity higher in RT
- But note: these changes are in top layers only

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Gadermaier et al., 2012: Renewable Agriculture Food Systems

Factors affecting yield in min till systems

Positive effect

- Greater potential for N mineralization i.e. larger organic N pool in surface soil
- Higher microbial activity and turnover of nutrients
- Water conservation
  - E.g. results of Frick tillage trial in some years RT>CT due to higher water retention

Some take home messages from the literature on RT in organic systems

- The right techniques & methods are essential for success e.g. importance of “two layer plough” (see Mäder & Berner, 2012)
- Choice of crop rotation to ensure weed and disease control and nitrogen availability (Peigné, 2007)
- High standard of management required, tailored to local soil and site conditions (Peigné, 2007)
- Reduced tillage comparable to regularly ploughed reference system if at least a shallow turning of the soil is carried out (Schulz et al. 2008)

Thanks and questions??

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