CASEE
Central and South Eastern Europe

University of Natural Resources
and Life Sciences, Vienna
Department of Crop Sciences

Long-term tillage experiment under Pannonian climate conditions at the Experimental Farm of the University of Natural Resources and Life Sciences (BOKU)

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8th International Conference CASEE
at the Warsaw University of Life Sciences

Content

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- Short facts about agriculture in Austria
- Applied Soil Tillage Systems
- Long-term tillage experiment under Pannonian climate
    - Experimental design
    - Research questions
    - Selected results
- Possible topics for collaboration in EFNet




Agriculture in Austria

Land use :

Total area: 8,39 Mio ha

Grassland: ~ 1.9 Mio ha (22%)

Arable land: ~ 1.4 Mio ha (17%)

Forests: ~ 3.8 Mio ha (46%)

Others: ~ 1.2 Mio ha (15%)

Agricultural land use mostly limited by:

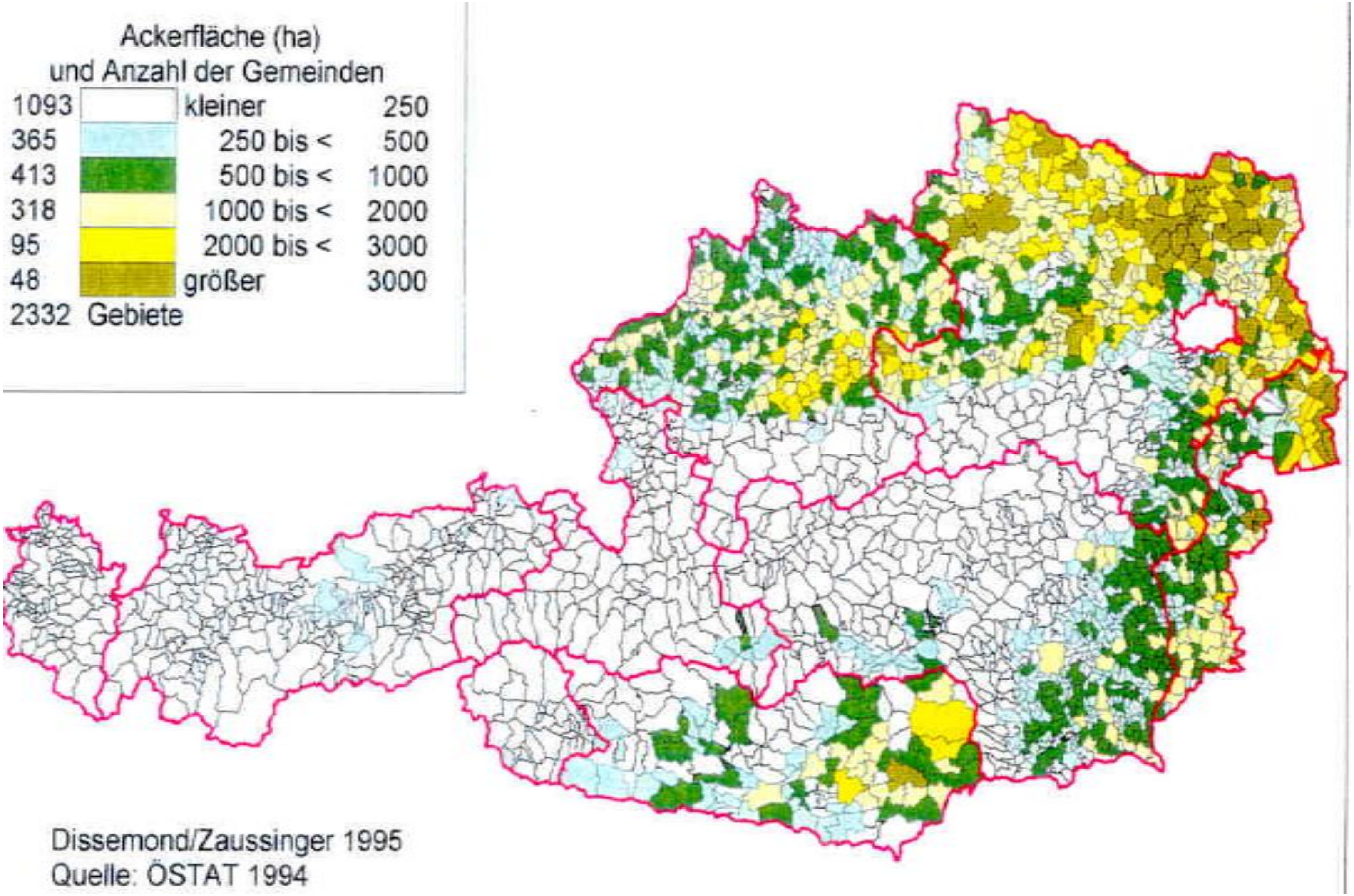
topography,

temperature

soil conditions

Precipitation

Arable land use in Austria



Classification of soil tillage systems according intensity and soil covering

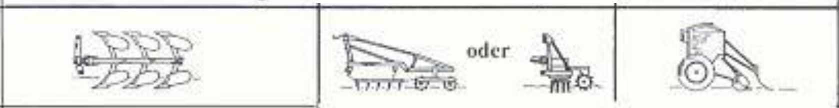
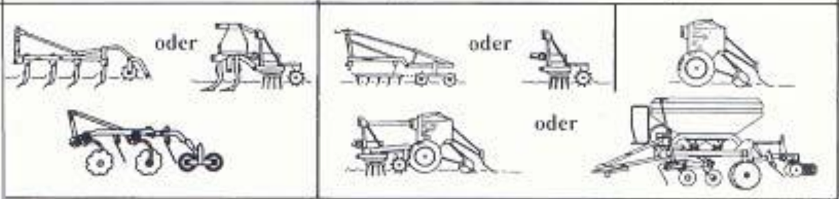
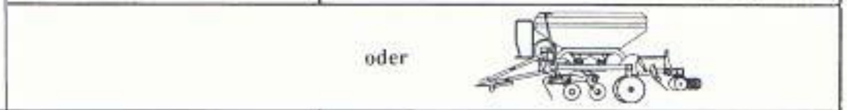
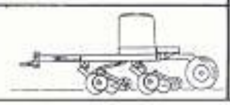
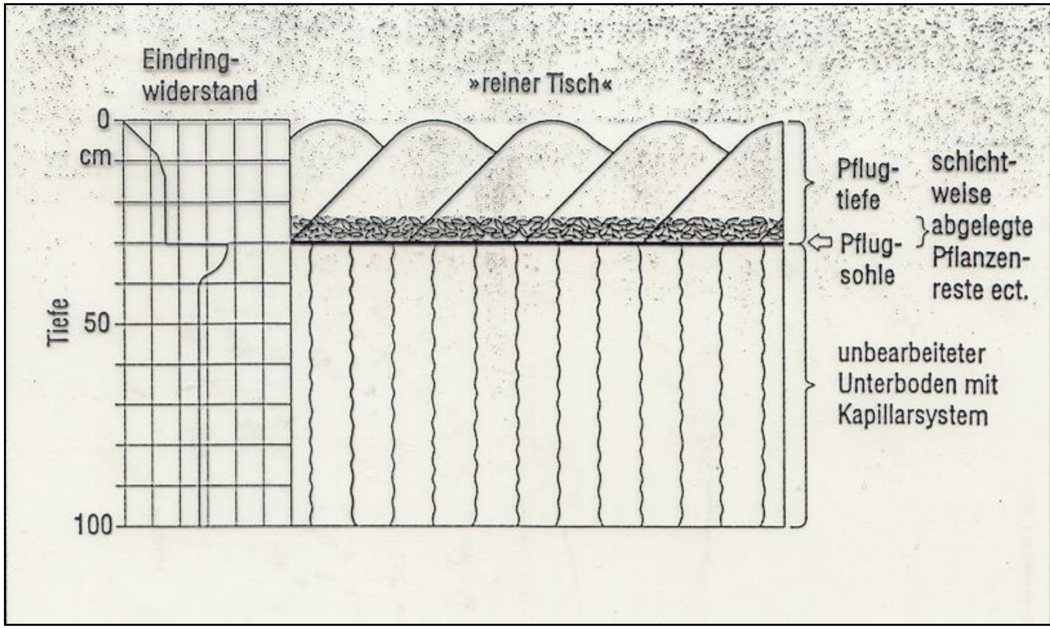
Tillage systems		Primary tillage / Secondary tillage / Seeding	Soil covering with plant residues after seeding
Conventional tillage	inverting		bis 15% oder 560 kg/ha
	Non-inverting		15 - 30% oder 560 - 1120 kg/ha
Conservation tillage	Mulch - seeding, Non-inverting	 	> 30 % oder > 1120 kg/ha
	„Strip seeding“ Loosening of strips		
	„Direct seeding“ No-till		

Bild 2: Einteilung der Bodenbearbeitungsverfahren

Nach Loibl & Köller (**Landtechnik Sonderheft 2006**)

Primary tillage with plough



Advantages:

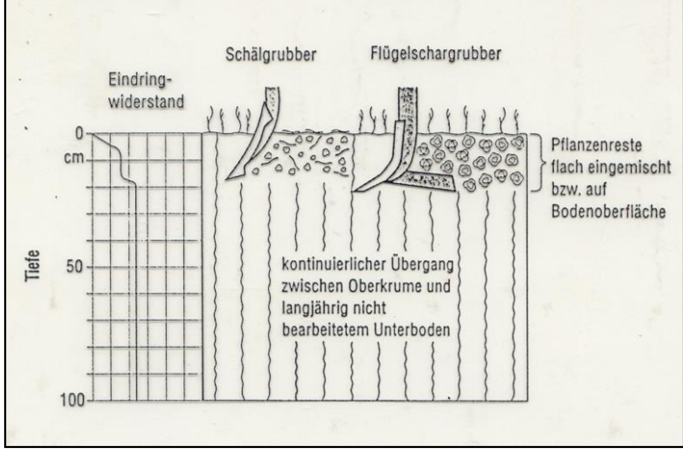
- „clean“ soil surface
- Increased mineralisation
- Mechanical weeding

Disadvantages:

- High demand of drawbar performance (15 – 25 kW/m working width) and fuel (=energy)
- Declining of the aggregate stability through decompostion of the organic matter
- Risk of soil erosion
- Plough-pan compaction
- Overloosening – recompaction is necassary

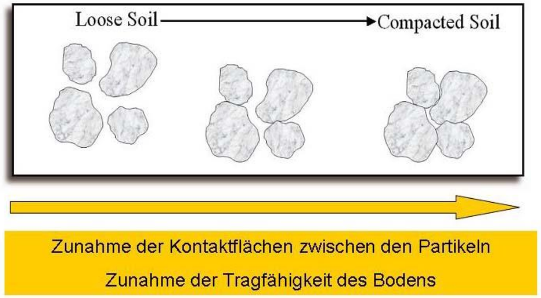
Conservation tillage

....Conservation of the soil structure...



Advantages:

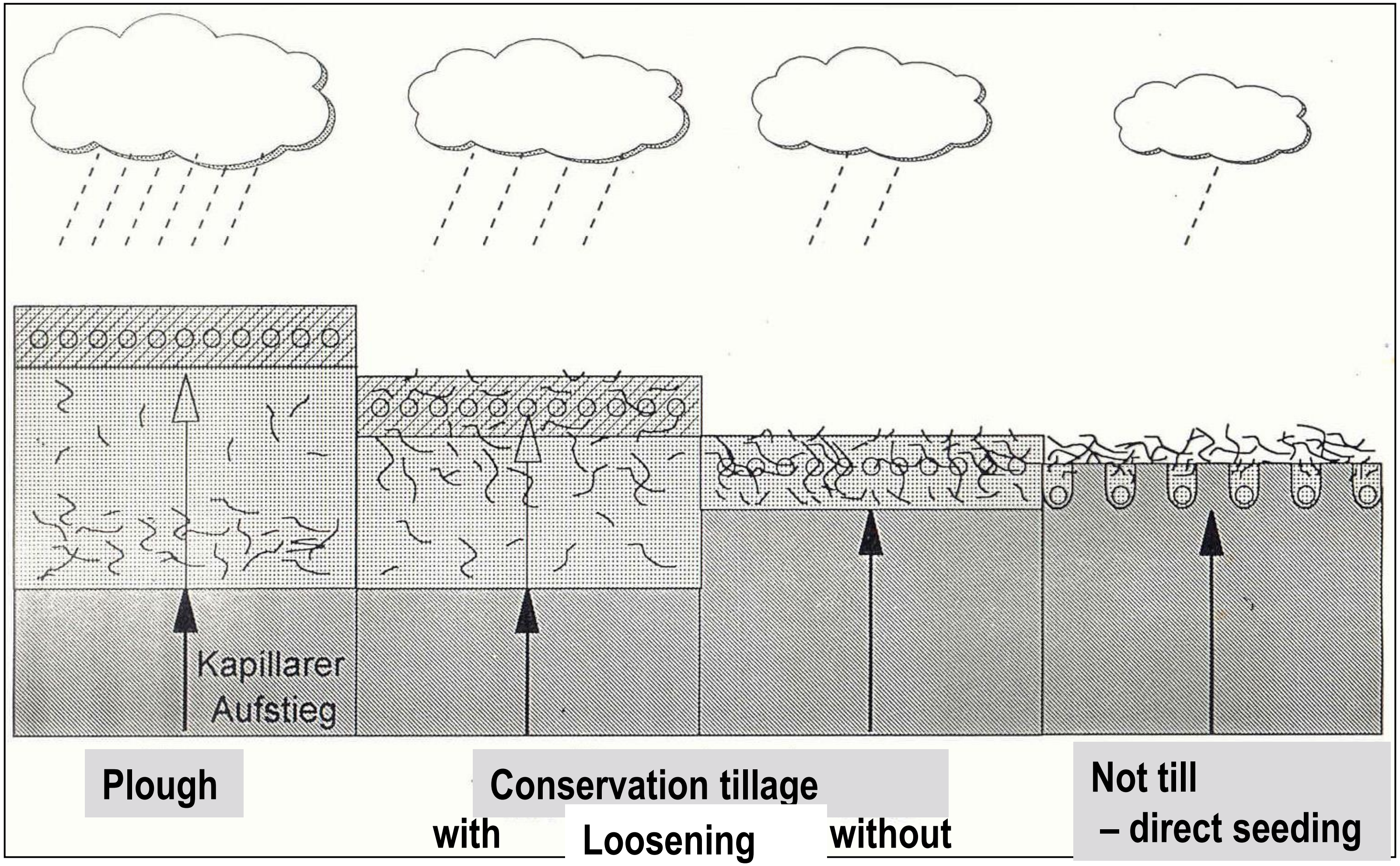
- Saving of fuel and costs
- Promotion of the soil organism activity (stratification of the mikrobiell activity, higher density of earthworms, etc.)
- Improvement of the water infiltration capacity
- Higher rootlength density and better exploitation of the subsoil for water and nutrients.
- Prevention of silting and erosion.
- Reduced run-off
- Higher carrying capacity of the soil



Disadvantages:

- High amount of plant residues at the surface can impede seeding.
- Changed nitrogen mineralisation cycle (reduced yields?)
- Weed – especially annual weeds
- Soil-borne diseases (z.B. Fusarium) can be increased
- Accumulation of nutrients at the top soil.

Climate-dependent tillage systems



Mechanical/biological soil tillage

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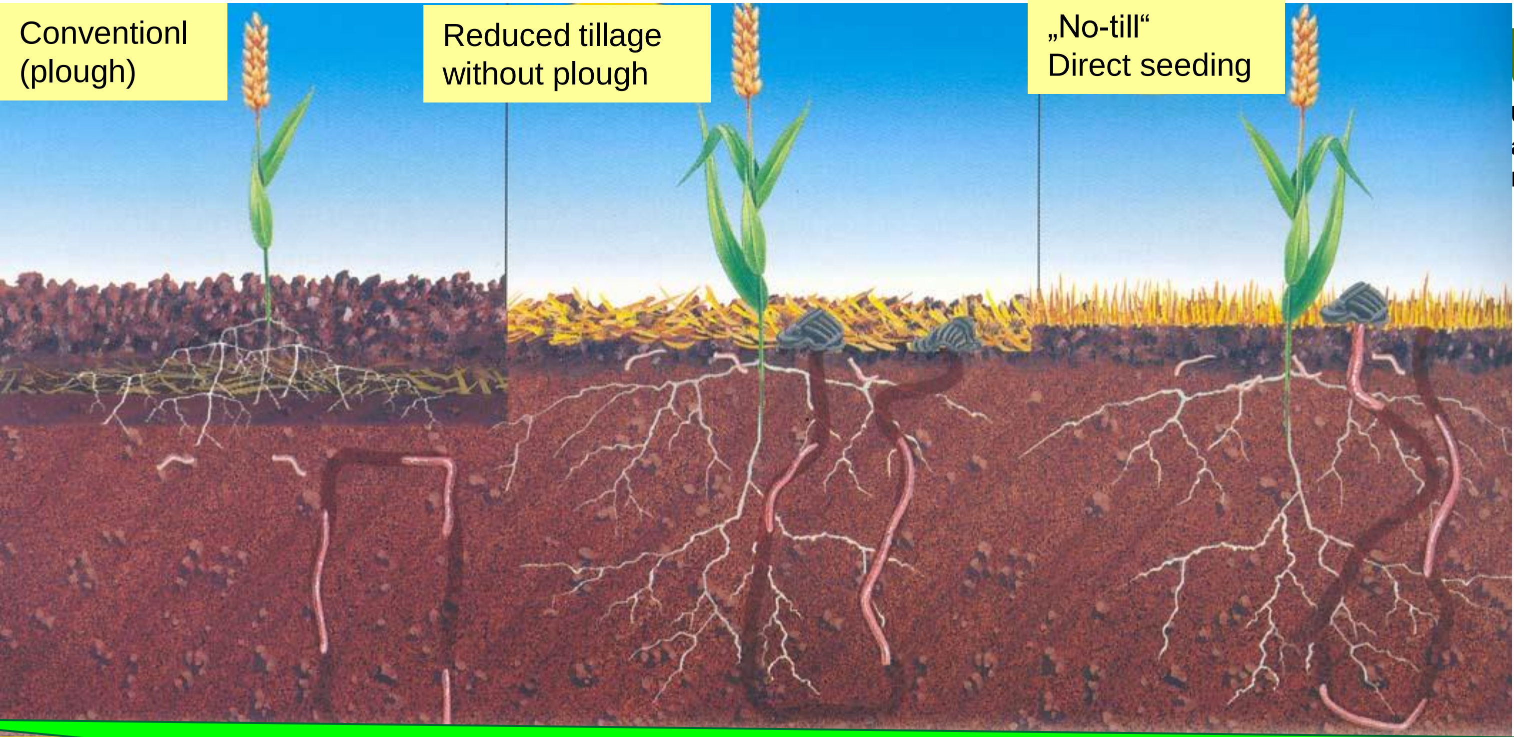

Bildquelle:
Bourguignon, 2000

Soil organism:

app. 25 t/ha Flora

app. 5 t/ha Fauna

mechanical **biological**

37 l/ha	28 l/ha	10 l/ha	Fuel consumption for tillage and seeding
1 – 20 mm/h	50 - 80 mm/h	80 - 100 mm/h	Infiltration rate

Eroded soils

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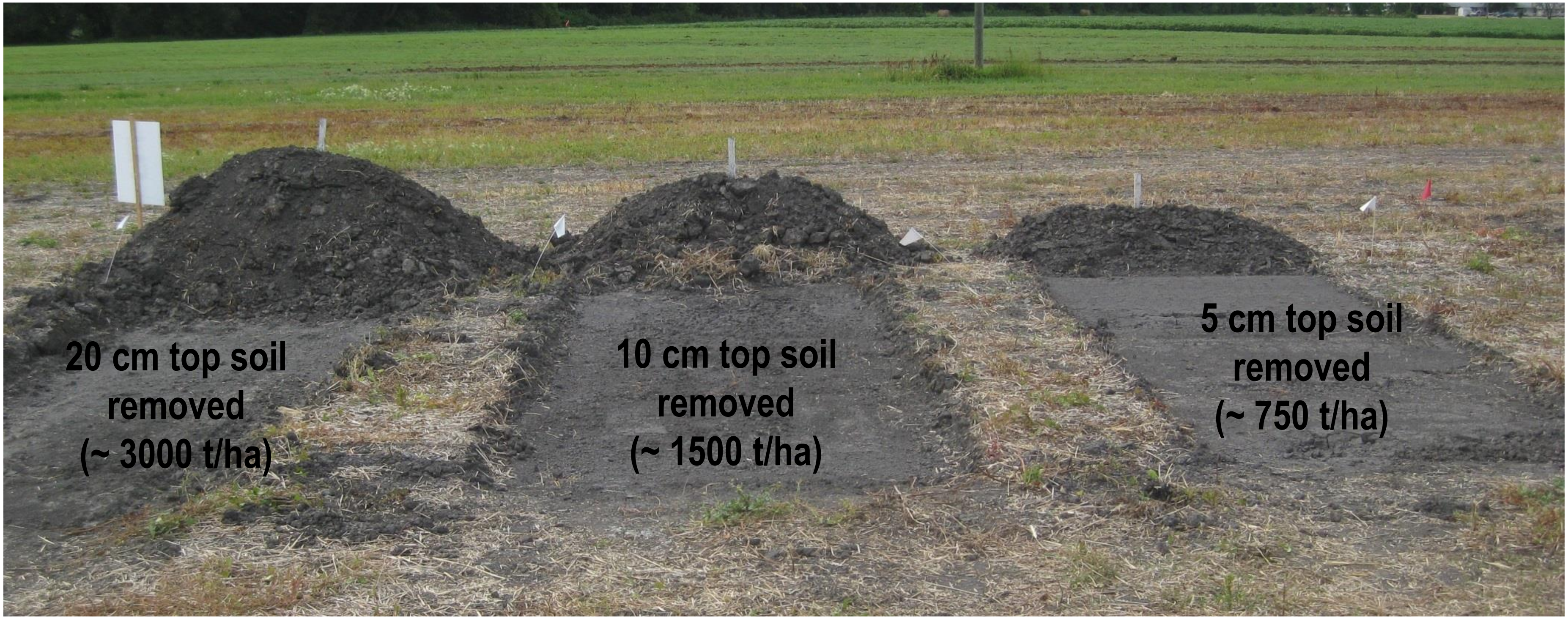
Soil and Manure Management Field Clinic in Portage la Prairie, Manitoba
5. August 2011



Erosion mitigation trough conservation tillage

Results from Austrian long-term trials (Klik, Rosner 2013)

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Mean measured erosion, run-off and yields (1994-2012),
Experimental site Mistelbach, Tulln, Pyhra

	Conventional tillage	Mulch seeding	Direct seeding, No-till
Soil erosion (t/ha)	10.0	2.3 **(-77 %)**	1.2 **(-88 %)**
C_{org} loss (kg/ha)	105	33 **(-67 %)**	17 **(-82 %)**
N loss (kg/ha)	14	6.9 **(-51 %)**	3.8 **(-73 %)**
P loss (kg/ha)	7	1.9 **(-73 %)**	0.9 **(-87 %)**
Run-off (mm)	25.0	21.3 **(-15 %)**	17.6 **(-30 %)**
Herbicid run-off		**- 50 %**	**- 90 %**
Yield	100	104	103

Direct Soil Erosion protection measurements

Situation in Austria

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Arable area: 1.369 Mio. Hectare

- **30 % (=418.800 ha):** Growing of **soil erosion sensitive crops** (maize, potatoe, sugar beet, sunflower, oil pumpkin, vegetable)
- **11 % (=150.590 ha):** Application of **conservation tillage** (Mulch or direct seeding)
- **36 % of soil erosion sensitive crops (=150.768):** Application of conservation tillage (Mulch or direct seeding) (financial support: 60 €/ha)
- **32 % Cropping of cover crops** (financial support: 120-200 €/ha)

Source: Evaluierungsbericht 2010, Maßnahme 214, S. 249, in Zukunft Pflanzenbau – pflanzenbauliche Grundlagen, AGES

Long-term tillage experiment

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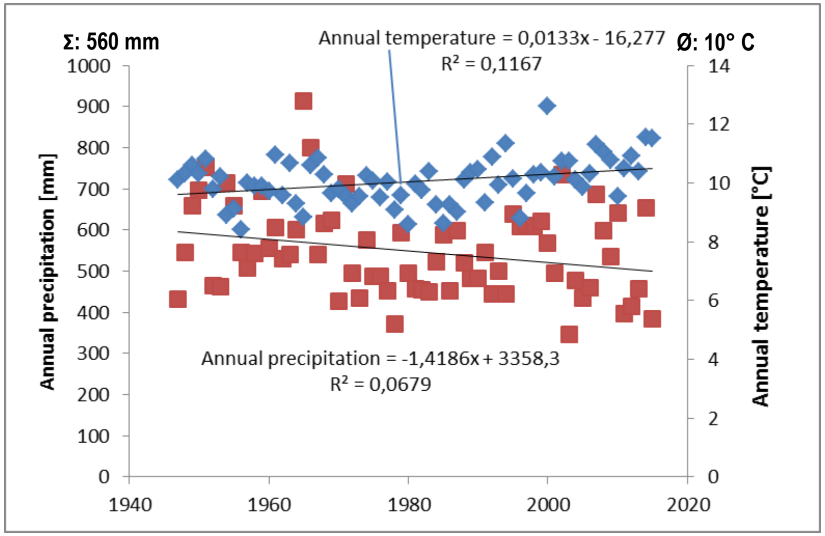
- **Established:** 1998
- **Location**: East of Vienna on the edge of **Marchfeld plain** (part of the Pannonian Basin)
- **Soil:** chernozem of alluvial origin and is rich in calcareous sediments (pHCaCl_2: 7.6, soil organic carbon: 2.3%).
- **Climate (1980-2009)**: 10.6° C, 538 mm
- **Treatments:**
  - 5 Soil tillage systems
  - 2 crop rotations



Annual precipitation and temperature at the experimental site between (between 1944 and 2015).

Experimental design

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Tillage systems:

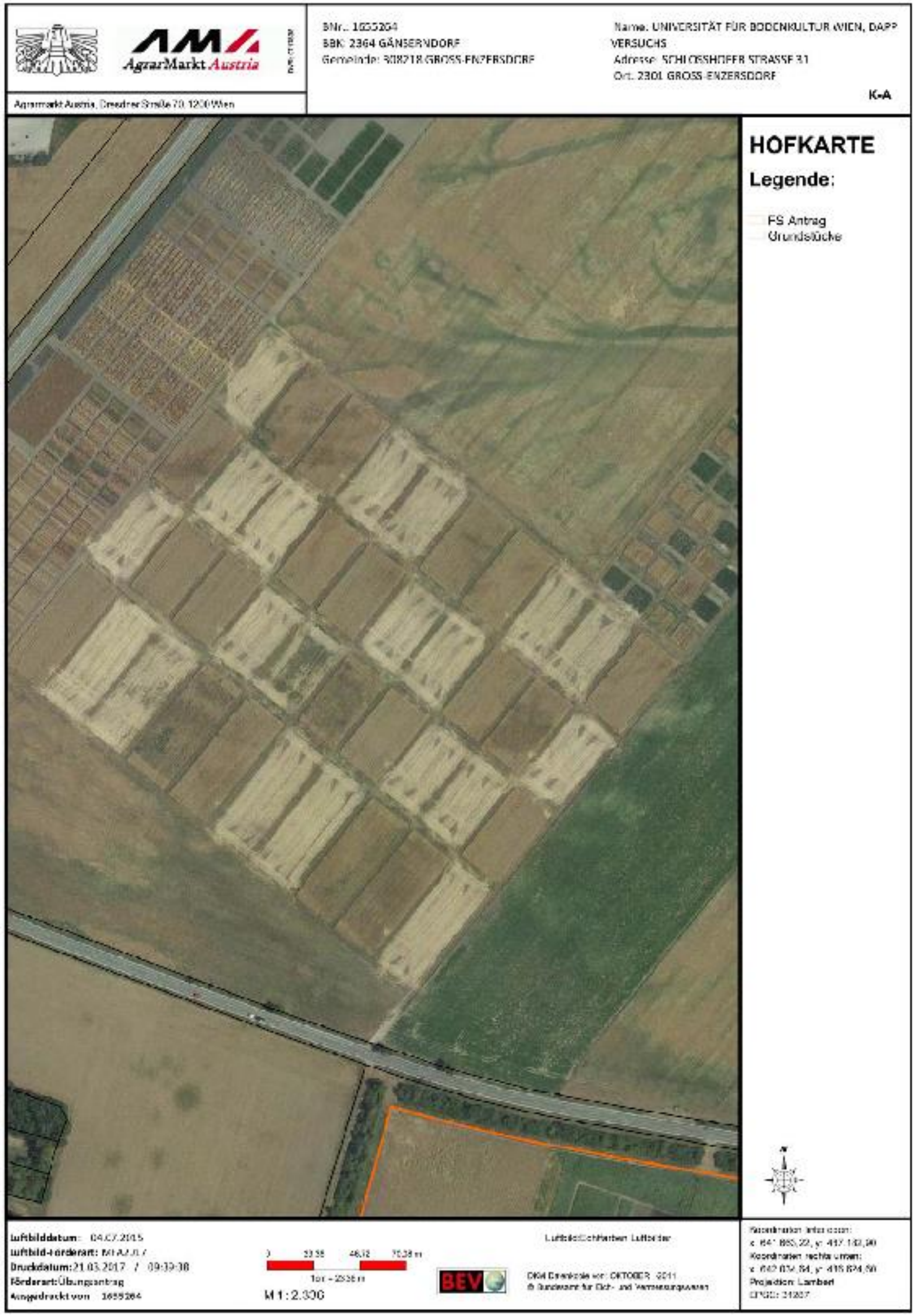
1: Mouldboard plough (25/30 cm)

2: No-till

3: Conservation Tillage [Wing sweep cultivator (16/20 cm) + Subsoiler (35 cm)]

4: Conservation Tillage [Wing sweep cultivator (8/10 cm)]

5: Integrated tillage system [Wing sweep cultivator (12/15 cm)], crop-specific application of mouldboard plough



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Crop rotations

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Year	Rotation A	Rotation B
1997	Sugar beet	Maize[1)]
1998	Winter wheat	Winter wheat
1999	Sun flower[1)]	Oilseed rape
2000	Winter wheat[2)]	Winter wheat[2)]
2001	Sugar beet	Sojabohne
2002	Winter wheat	Winter wheat
2003	Maize	Oilseed rape
2004	Winter wheat	Winter wheat
2005	Sugar beet	Maize
2006	Durum wheat	Winter wheat
2007	Winter wheat	Maize
2008	Maize	Winter wheat
2009	Winter wheat	Maize
2010	Sugar beet	Winter wheat
2011	Winter wheat	Sugar beet
2012	Winter wheat	Winter wheat
2013	Soybean	Maize
2014	Sugar beet	Summer wheat
2015	Winter wheat	Oilseed rape
2016	Maize	Soybean
Leave crops:cereals	35 % :65 %	30 % : 70 %
% Wheat	50 %	45 %

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Detected parameters

Each year:

- Agronomic parameters (crop yield, DM-Content, e.g.)

Selected Years:

- Soil parameters:
  => chemical (N, P_2O_5, K_20, C_{org})

  => physical (bulk density, soil penetration resistance, soil water content, water infiltration rate)
- Fuel consumption for tillage processes
- Specific research questions like: weed infestation

Research questions:

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(Long-term) effects of tillage systems on:

⇒ **Agronomy parameters** (qualitative and quantitative yield)

⇒ **Soil physics parameters** (soil water content, bulk density, soil resistance, hydraulic conductivity)

⇒ **Soil chemistry parameters** (e.g. C_{org}-content, N_{min},…)

⇒ **Weed infestation** and **plant health**

⇒ **Process parameters (**e.g. fuel consumption, work time requirement)

⇒ **Energy efficiency** and **Life Cycle Assessment (LCA)**

⇒ **Long-term effect of glyphosate application in no-tillage**

⇒ **Economy (e.g. profitability**)

Master thesis based on the tillage experiment (I)

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Kempl, Fritz (1997): Effect of different tillage and weeding treatments on growth pattern and ingredients of sugar beet.

Summerer, Harald (1998): Effect of tillage treatments of root development, yield and ingredients of sugar beet.

Schlögl, Heinz (1998): Effect of different tillage and weeding treatments on growth pattern and ingredients of sugar beet.

Höllmüller, Rainer (1998): Effect of tillage treatments on germination, yield and weed infestation of maize.

Köck, Manfred (1998): Effect of tillage treatments on root development, nitrogen content and yield of maize.

Sachsen-Coburg und Gotha, Maximilian (2000): Influence of different tillage treatments on development and yield of rape seed.

Master thesis based on the tillage experiment (II)

University of Natural Resources
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Schmutzer, Gerd (2002): Effect of different tillage treatments on N dynamic, soil penetration resistance, field emergence, yield and quality of sugar beet (Beta vulgaris L. ssp. Vulgaris var. Altissima).

Rischbeck, Pablo Max (2004): Influence of soil tillage on soil water content.

Refenner, Johannes (2012): Influence of different tillage systems on yield and quality of sugarbeet in the semi-arid region.

Rauchberger, Edmund (2014): Long-term effect of different tillage treatments of selected soil parameters, growth pattern, and quality parameter of sugarbeet under Pannonian climate conditions.

Doctoral thesis based on the tillage experiment (II)

Wagentristl, Helmut (1998): Influence of different tillage systems on growth and development of sugar beet and their roots in the Pannonian climate region.

Szalay, Tibor (2015): Effect of different tillage systems on selected soil parameters, yield, fuel consumption and work time requirement in the semi-arid production area.

Tractor with measurement equipment for fuel consumption and slip

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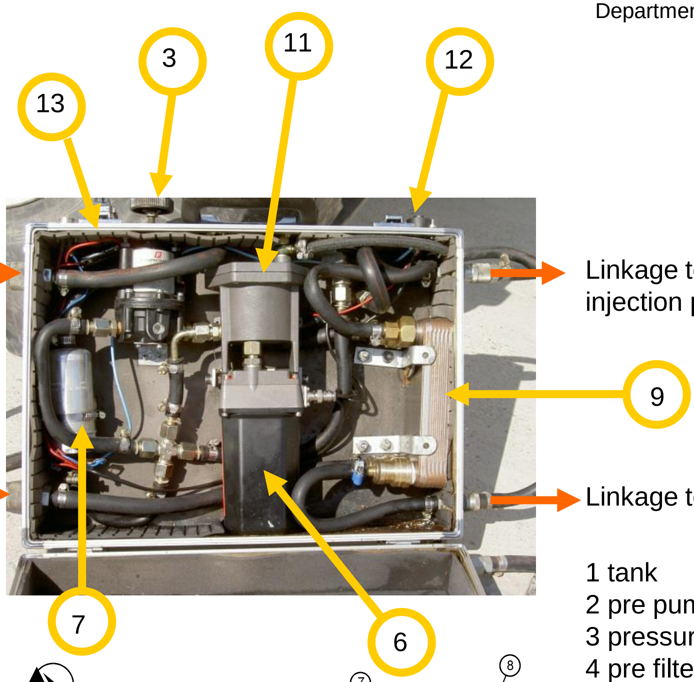
Linkage from fuel filter

Linkage from injection pump (leak diesel)

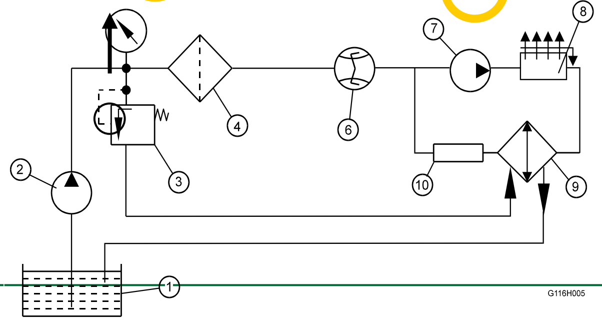


Linkage to fuel injection pump

Linkage to tank

Steyr 9125a

- Power: 92 kW (DIN)
- 6 stroke diesel engine with direct injection and exhaust turbo super charger
- Capactiy: 6600 cm^3
- Nominal rotation speed: 2300 rev/min
- Constant power range between 1900 – 2300 rev/min
- Gear box: 4 step power shift, forward/reverse group, main transmission 6 gears (synchronized). total: 24 forward and 24 reverse speeds
- weight: 5465 kg



1 tank
2 pre pump
3 pressure controller with manometer
4 pre filter
6 flowmeter PLU 116H
7 pump
8 injection pump
9 fuel/fuel-heat exchanger
10 control for leak flow
11 air bubble releaser
12 power supply
13 digital rectangular signal

Experimental Farm Groß-Enzersdorf

Tillage - 27th and 28th October 2005

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Seeding of winter wheat (28th October 2005)

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Seed preparation with power harrow (5th April 2005)

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Experimental Farm Groß-Enzersdorf

Results for Winterwheat

Fuel consumption for tillage and seeding

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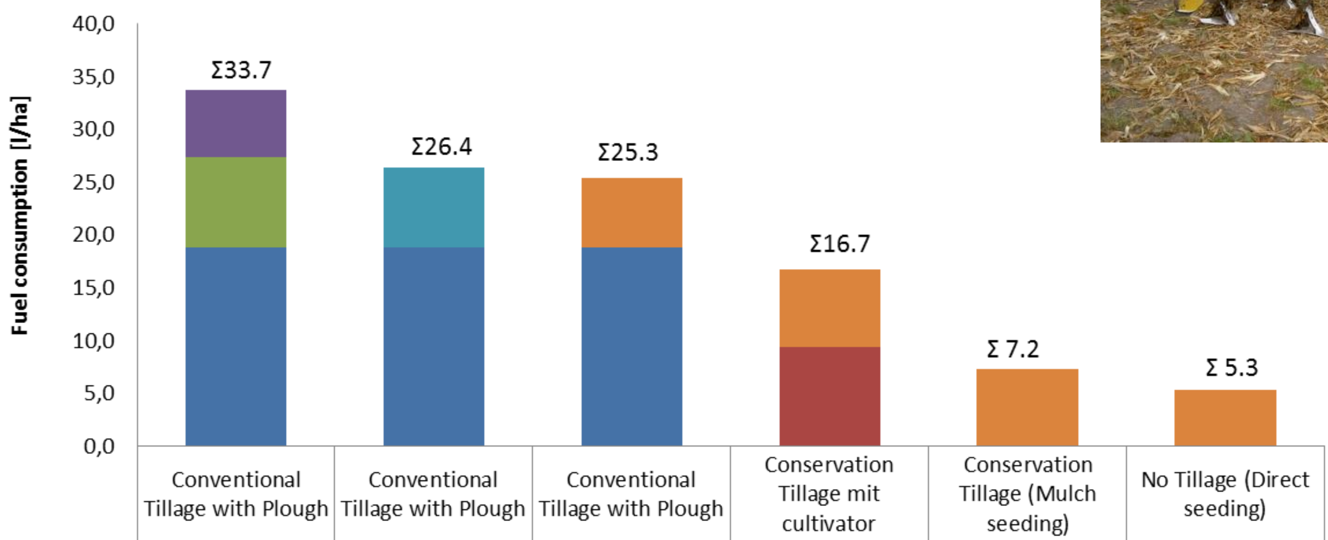

	Conventional Tillage with Plough	Conventional Tillage with Plough	Conventional Tillage with Plough	Conservation Tillage mit cultivator	Conservation Tillage (Mulch seeding)	No Tillage (Direct seeding)
Universal seed drill (Mulch/Directseeding)			6,6	7,3	7,2	5,3
Power harrow - seed drill combination		7,6				
Seed drill - 3 m, mechanical	6,3					
Power harrow - 3 m	8,6					
Wing sweep cultivator (3 m)				9,4		
Mouldboard Plough	18,8	18,8	18,8			

Experimental Farm Groß-Enzersdorf

Selected results for Winterwheat

Yield and energy efficiency

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	1998	2000	2002	2004	2006	2007	2008	2009	2010	2011	2012	2015	Mean
	Grain$^{1)}$ yield (kg ha^{-1})												
MP	2997$^{a2)}$	2959	3937	6082^{ab}	4090^{b}	3701	4751	4852	4969	4962	2377	3752	**4119**
CT$_d$	3238^{ab}	3297	4378	6486^{b}	3865^{b}	3933	5122	5630	4090	5028	2795	4302	**4347**
CT$_s$	3517^{ab}	3283	4121	6208^{ab}	4284^{b}	3942	5358	4869	4190	5404	2788	3839	**4317**
NT	3902^{b}	3547	3765	5548^{a}	2243^{a}	3923	5179	5352	3542	4601	2980	4134	**4060**
Mean	**3412** BC2)	**3271** B	**4050** DE	**6081** G	**3620** BCD	**3875** CDE	**5103** F	**5176** F	**4198** E	**4999** F	**2735** A	**4006** DE	**4211**
	Energy output (GJ ha^{-1})												
MP	45.3^{a}	44.8	60.4	94.7^{ab}	62.9^{b}	56.6	73.4	75.1	76.9	76.8	35.5	57.5	**63.3**
CT$_d$	49.2^{ab}	50.2	67.5	101.2^{b}	59.3^{b}	60.4	79.4	87.5	62.9	77.9	42.2	66.3	**67.0**
CT$_s$	53.7^{ab}	50.0	63.4	96.8^{ab}	66.0^{b}	60.5	83.2	75.3	64.5	83.9	42.0	58.8	**66.5**
NT	59.9^{b}	54.2	57.7	86.2^{a}	33.3^{a}	60.2	80.3	83.1	54.1	71.0	45.1	63.6	**62.4**
Mean	**52.0** BC	**49.8** B	**62.2** DE	**94.7** G	**55.4** BCD	**59.4** CDE	**79.1** F	**80.2** F	**64.6** E	**77.4** F	**42.3** A	**61.5** DE	**64.9**
	Net-Energy output (GJ ha^{-1})												
MP	36.1^{a}	35.6	51.2	85.5^{ab}	53.6^{b}	47.4	64.2	65.8	67.7	67.6	26.3	48.3	**54.1**
CT$_d$	40.0^{a}	40.9	58.2	91.9^{b}	50.0^{b}	51.1	70.1	78.2	53.6	68.6	32.9	57.1	**57.7**
CT$_s$	44.9^{ab}	41.2	54.6	87.9^{ab}	57.2^{b}	51.7	74.3	66.5	55.7	75.1	33.3	50.1	**57.7**
NT	51.0^{b}	45.4	48.8	77.3^{a}	24.5^{a}	51.4	71.4	74.2	45.3	62.2	36.3	54.8	**55.1**
Mean	**43.0** BC	**40.8** B	**53.2** DE	**85.6** G	**46.3** BCD	**50.4** CDE	**70.0** F	**71.2** F	**55.6** E	**68.4** F	**32.2** A	**52.6** DE	**55.8**
	Energy intensity (MJ kg^{-1} dry grain$^{1)}$)												
MP	2.71	2.71	2.03	1.31^{a}	1.94^{a}	2.20	1.73	1.64	1.60	1.62a	3.37	2.23	**2.09**
CT$_d$	2.54	2.48	1.88	1.23^{a}	2.06^{a}	2.05	1.57	1.41	2.03	1.59a	2.85	1.86	**1.96**
CT$_s$	2.34	2.53	2.00	1.28^{a}	1.91^{a}	2.05	1.51	1.64	1.90	1.48a	2.91	2.21	**1.98**
NT	2.22	2.51	2.37	1.59^{b}	5.13^{b}	2.19	1.67	1.62	2.65	1.87b	2.91	2.09	**2.40**
Mean	**2.45** B	**2.56** B	**2.07** AB	**1.35** A	**2.76** B	**2.12** AB	**1.62** A	**1.58** A	**2.05** AB	**1.64** A	**3.01** C	**2.10** AB	**2.11**
	Mean energy output/input-ratio												
MP	4.91^{a}	4.86	6.54	10.2	6.81^{b}	6.13	7.94	8.11	8.31	8.30	3.85^{a}	6.27	**6.85A**
CT$_d$	5.31^{a}	5.41	7.27	10.9	6.39^{b}	6.51	8.54	9.40	6.77	8.37	4.55^{ab}	7.20	**7.21AB**
CT$_s$	6.11^{ab}	5.69	7.20	11.0	7.50^{b}	6.88	9.43	8.55	7.33	9.52	4.79^{ab}	6.75	**7.56B**
NT	6.78^{b}	6.14	6.53	9.7	3.78^{a}	6.81	9.07	9.37	6.13	8.03	5.12^{b}	7.26	**7.06AB**
Mean	**5.78** BC	**5.52** B	**6.89** D	**10.4** F	**6.12** BCD	**6.58** CD	**8.74** E	**8.86** E	**7.14** D	**8.56**	**4.58** A	**6.87** D	**7.17**

MP: Mouldboard plough
CT$_d$: deep conservation tillage
CT$_s$: shallow conservation tillage
NT: No tillage

Climatic conditions (year effect) overlay the effect of tillage system!!!

[1)] 14% moisture content ; [2)] Statistically significant differences (Student-Newman-Keuls procedure ; $p<0.05$) are shown for the year effect with capital letters and for the tillage effect with small letters

Impact of soil cultivation on soil water storage

(Eitzinger et al., 2004)

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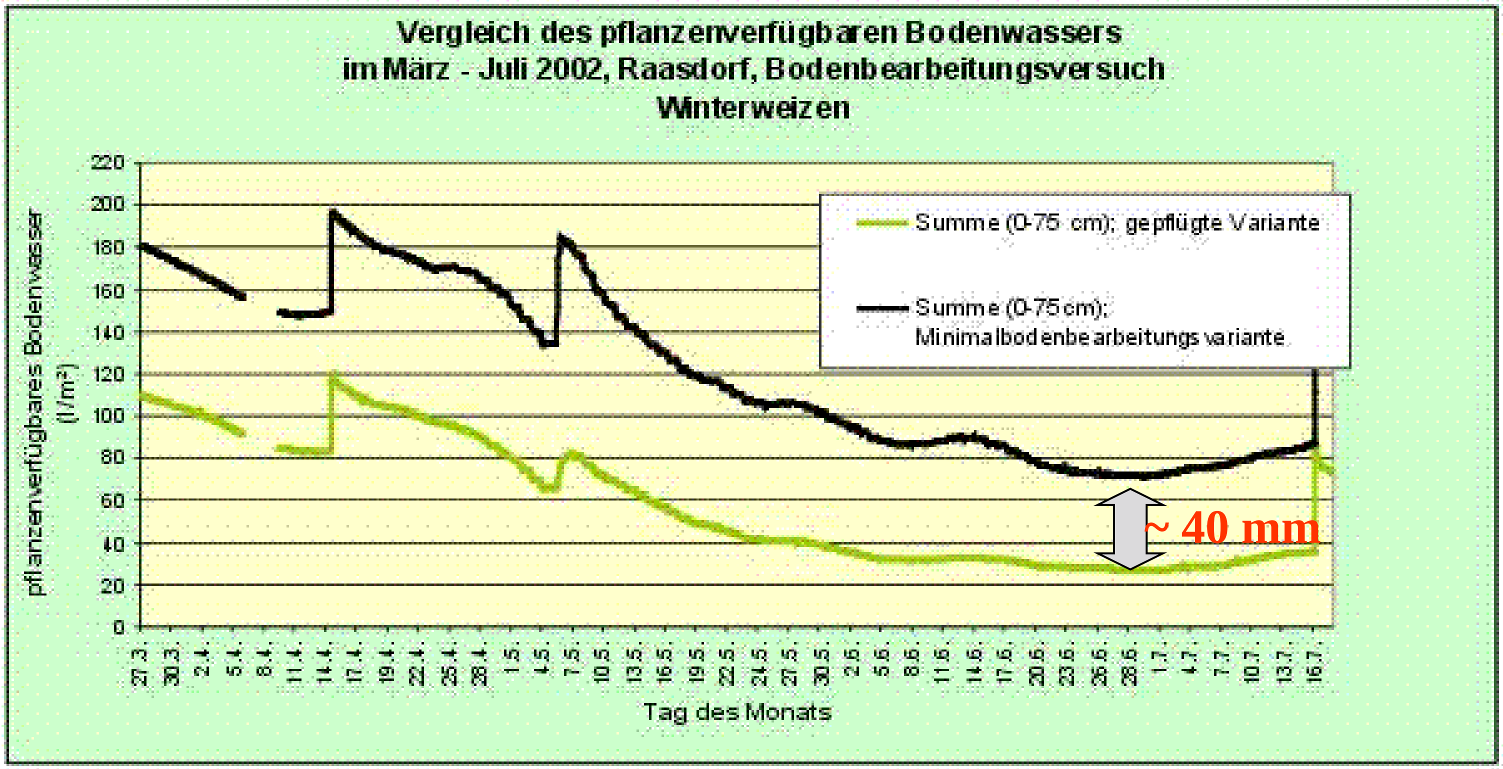

Mean transpiration via plants::

~8 l/m² and day

Impact of soil cultivation on rut depth and soil water content

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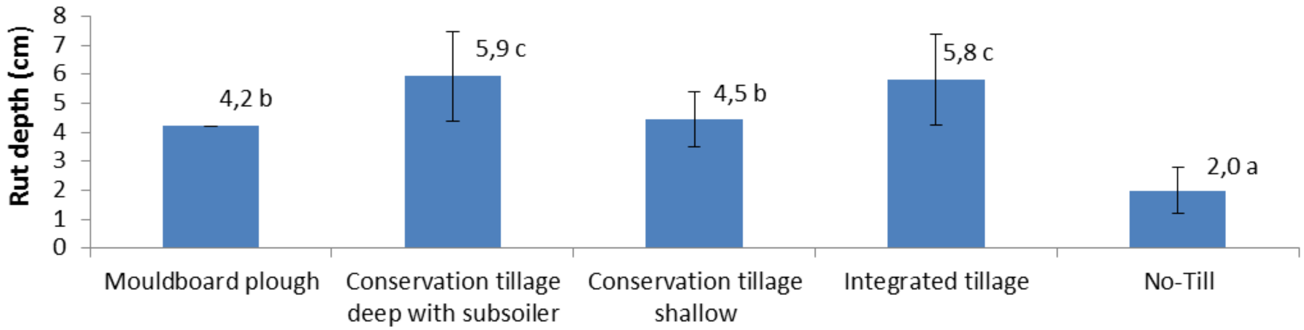
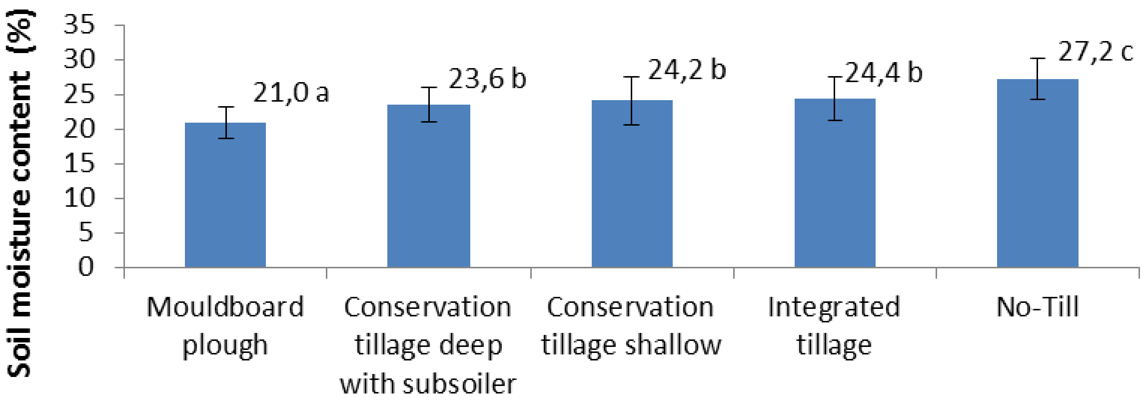
Rut depth (N = 64 per tillage treatment)



Soil moisture content (N = 28 per tillage treatment)



Rear Wheel load: 1400 kg

Multiple comparison test according Student-Newman-Keuls, $p<0,05$

Measurements from 23th March 2017

Experimental Farm Groß-Enzersdorf

Summary

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• Conservation tillage systems in the pannonian region save **energy and soil water** (=> yield effect).

• The tillage experiment offers for students in agricultural and natural sciences **topics for master thesis**.

Possible topics for collaboration in the EFNet

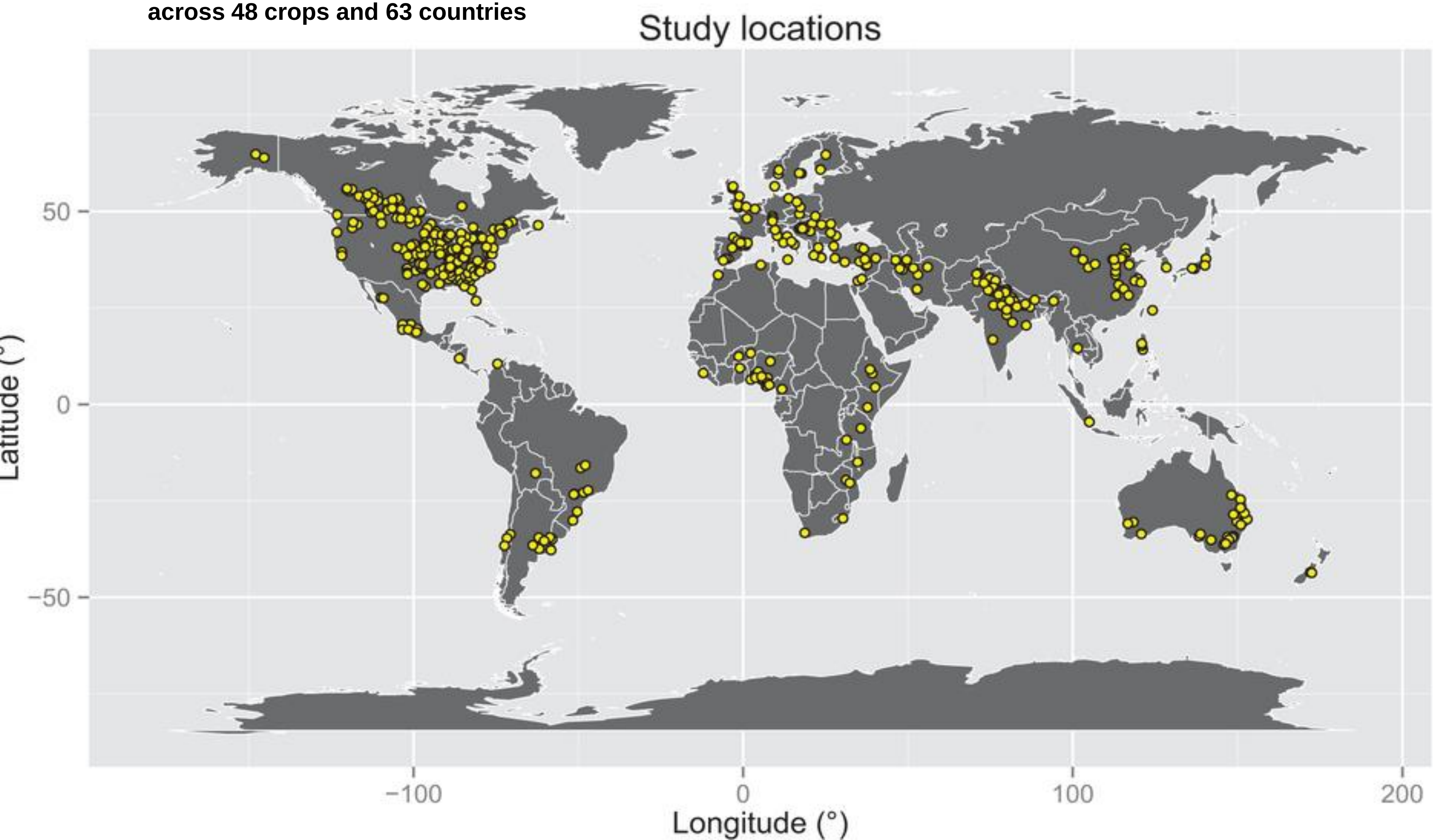
- **Comparison of yield effect** in humid region and other soils in EFNet
- **Energy efficiency** in comparison other tillage experiments in EFnet.
- **Weed infestation** in comparison to other tillage experiments in EFnet.
- **Residues of Glyphosat** and AMPA in the No-till treatment (1997-2012: 31,5 kg/ha)
- etc.

Thank you for your attention

CM Pittelkow *et al. (2015):* **Productivity limits and potentials of the principles of conservation agriculture.**
Nature 517, 365-368 (2015) doi:10.1038/nature13809

University of Natural Resources

5,463 paired yield obersations from 610 studies to compare not-till with conventional tillage practices across 48 crops and 63 countries



Comparison of yield in no-till versus conventional tillage systems in relation to the other two principles of conservation agriculture.

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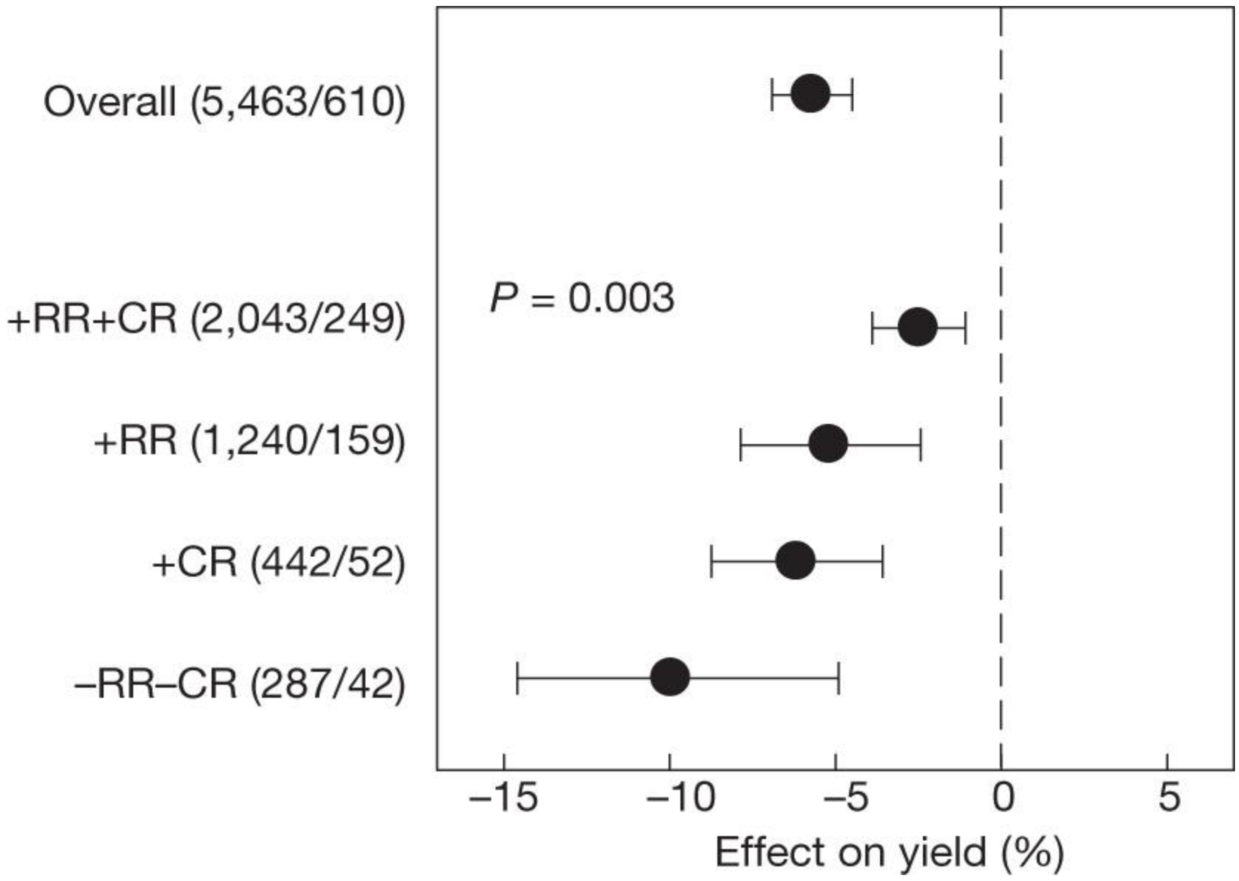

Results are shown for the entire data set (overall) and for subcategories of studies which indicated the presence or absence of residue retention and crop rotation for both no-till and conventional tillage systems: +RR+CR (residue retention + crop rotation), +RR (residue retention), +CR (crop rotation), or –RR–CR (without residue retention or crop rotation). The number of observations and total number of studies included in each category are displayed in parentheses. Error bars represent 95% confidence intervals. Significant differences between categories are indicated by *P* values based on randomization tests.

CM Pittelkow *et al. (2015):* Productivity limits and potentials of the principles of conservation agriculture.
***Nature 517*, 365-368 (2015) doi:10.1038/nature13809**

Comparison of rainfed crop yield in no-till versus conventional tillage systems in relation to the other two principles of conservation agriculture as a function of climate.

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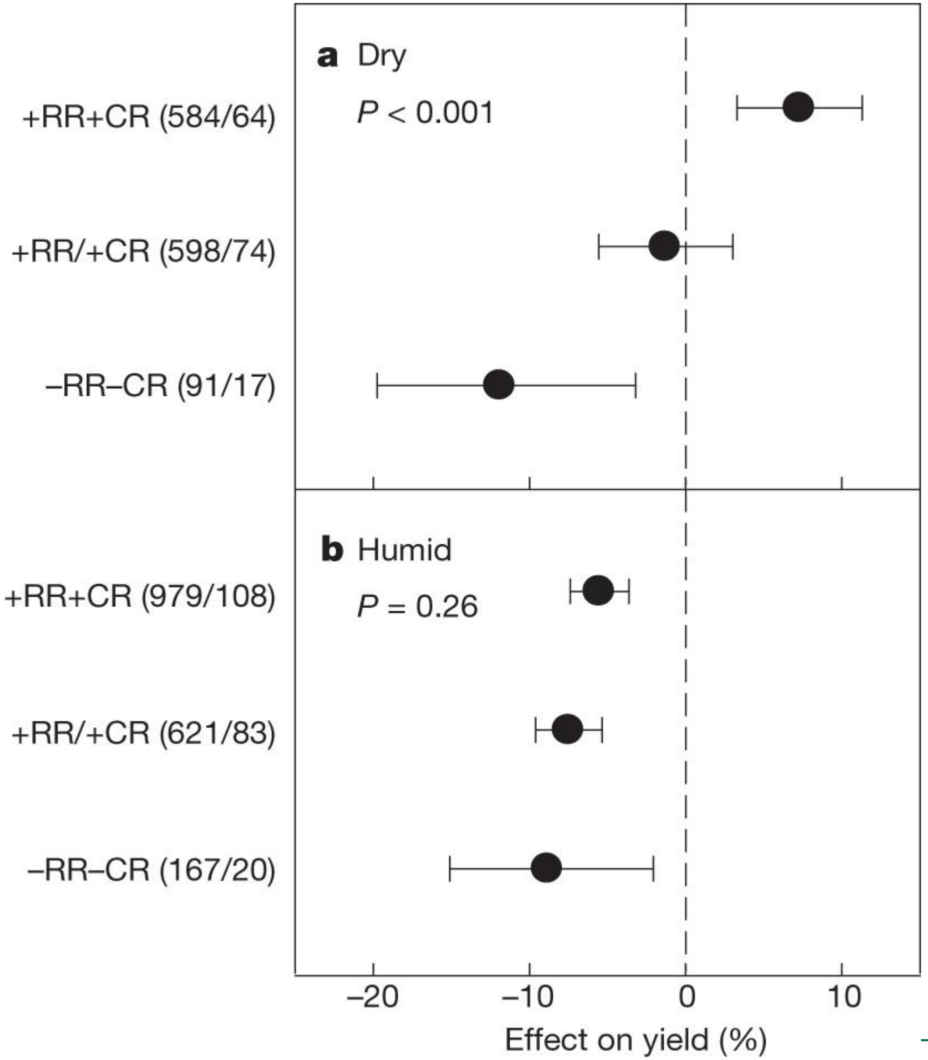

The influence of (a) 'Dry' and (b) 'Humid' climates, defined by aridity index values (mean annual precipitation divided by potential evapotranspiration) less or more than 0.65, respectively. Categories represent studies that indicated the presence or absence of residue retention and crop rotation for both no-till and conventional tillage systems: +RR+CR (residue retention + crop rotation), +RR/+CR (either residue retention or crop rotation), or –RR–CR (without residue retention or crop rotation). The number of observations and total number of studies included in each category are displayed in parentheses. Error bars represent 95% confidence intervals. Significant differences between categories are indicated by *P* values based on randomization tests.

CM Pittelkow *et al. (2015):* Productivity limits and potentials of the principles of conservation agriculture. *Nature 517*, 365-368 (2015) doi:10.1038/nature13809

Comparison of yield in no-till versus conventional tillage systems in relation to the other two principles of conservation agriculture over time.

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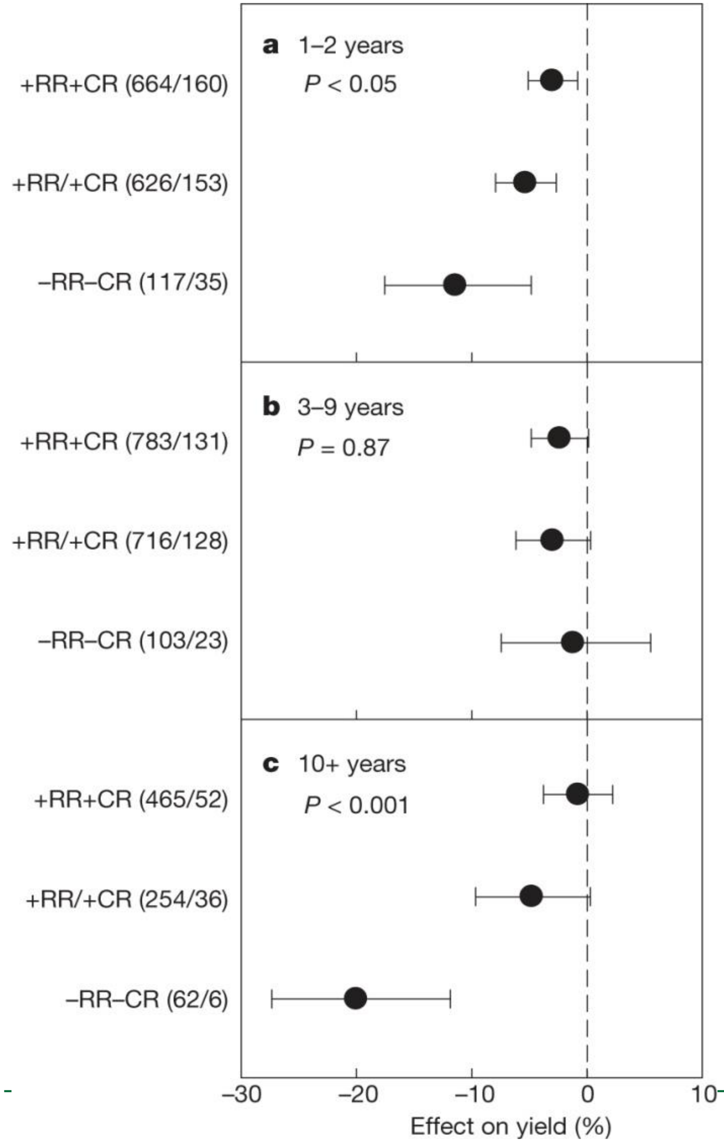

The influence of (a) 1–2, (b) 3–9, and (c) 10+ years following no-till implementation. Categories represent studies that indicated the presence or absence of residue retention and crop rotation for both no-till and conventional tillage systems: +RR+CR (residue retention + crop rotation), +RR/+CR (either residue retention or crop rotation), or –RR–CR (without residue retention or crop rotation). The number of observations and total number of studies included in each category are displayed in parentheses. Error bars represent 95% confidence intervals. Significant differences between categories are indicated by *P* values based on randomization tests.

CM Pittelkow *et al. (2015):* Productivity limits and potentials of the principles of conservation agriculture.
***Nature 517*, 365-368 (2015) doi:10.1038/nature13809**

Selected results for Winterwheat

Total fuel consumption

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Operation	Mouldboard plough (MP)	Deep Conservation tillage (CT_d)	Shallow conservation tillage (CT_s)	No-Tillage (NT)
Stubble cultivation[1)]	5.7	5.7	5.7	–
Ploughing[1)]	18.8	–	–	–
Wing sweep cultivator[1)]	–	9.4	6.7	–
Subsoiling[1)]	–	9.4	–	–
Seeding[2)]	6.6	7.3	7.3	5.3
Spreading fertilizer[3)]	3.0	3.0	3.0	3.0
Spraying herbicide[3)]	2.0	2.0	2.0	4.0
Harvesting[3)]	22.0	22.0	22.0	22.0
Transport (5 km)[3)]	1.7	1.8	1.8	1.7
Total	**59.8**	**60.6**	**48.5**	**36.0**

[1)] Szalay et al., 2015; [2)] Moitzi et al., 2013a; [3)] ÖKL, 2013

Results for Maize

Yield and energy efficiency

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	2003	2005	2008	2009	2013	2016	Mean
	Grain[1] yield (kg ha^{-1})						
MP	6562	9916	9378	10465	7340	7192	**8476**
CT_d	6513	9639	10378	11302	6976	6777	**8597**
CT_s	6397	9769	9812	10939	7493	6753	**8527**
NT	7322	10217	8707	10165	8360	7314	**8681**
Mean	**6698$^{A)}$**	**9885^{B}**	**9569^{B}**	**10718^{C}**	**7542^{A}**	**7009^{A}**	**8570**
	Energy output (GJ ha^{-1})						
MP	108,7	164,5	155,5	173,6	121,6	119,2	**140,5**
CT_d	107,9	159,9	172,1	187,5	115,6	112,3	**142,5**
CT_s	106,0	162,0	162,7	181,5	124,2	111,9	**141,4**
NT	121,3	169,5	144,4	168,6	138,6	121,2	**143,9**
Mean	**111,0^{A}**	**163,9^{B}**	**158,7^{B}**	**177,8^{C}**	**125,0^{A}**	**116,1^{A}**	**142,1**
	Net-Energy output (GJ ha^{-1})						
MP	90,3	144,1	135,0	153,2	99,9	100,3	**120,5**
CT_d	89,2	139,6	151,1	166,8	94,7	93,7	**122,5**
CT_s	88,0	142,2	142,4	161,4	102,8	93,7	**121,8**
NT	103,0	149,6	125,0	149,0	116,7	102,9	**124,4**
Mean	**92,6^{A}**	**143,9^{B}**	**138,4^{B}**	**157,6^{C}**	**103,6^{A}**	**97,7^{A}**	**122,3**
	Energy intensity (MJ kg^{-1} dry grain[1])						
MP	2,81	2,06	2,20	1,95	3,14	2,62	**2,46**
CT_d	2,90	2,10	2,07	1,85	3,00	2,74	**2,44**
CT_s	2,87	2,04	2,10	1,84	2,87	2,71	**2,40**
NT	2,53	1,95	2,27	1,95	2,67	2,50	**2,31**
Mean	**2,77^{CD}**	**2,04^{AB}**	**2,16^{B}**	**1,90^{A}**	**2,92^{D}**	**2,64^{C}**	**2,40**
	Mean energy output/input-ratio						
MP	5,92	8,08	7,56	8,53	5,54	6,33	**6,99**
CT_d	5,77	7,89	8,15	9,05	5,54	6,05	**7,07**
CT_s	5,88	8,17	7,99	9,05	5,81	6,14	**7,17**
NT	6,60	8,52	7,44	8,57	6,30	6,63	**7,34**
Mean	**6,06^{A}**	**8,16^{B}**	**7,78^{B}**	**8,80^{C}**	**5,80^{A}**	**6,29^{A}**	**7,14**

MP: Mouldboard plough
CT_d: deep conservation tillage
CT_s: shallow conservation tillage
NT: No tillage

[1] 14% moisture content ; [2] Statistically significant differences (Student-Newman-Keuls procedure ; p<0.05) are shown for the year effect with capital letters and for the tillage effect with small letters

Selected results for maize

Fuel consumption (L ha^{-1}) for maize in different tillage systems

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Operation	Mouldboard plough (MP)	Deep Conservation tillage (CT_d)	Shallow conservation tillage (CT_s)	No-Tillage (NT)
Stubble cultivation [a]	5.7	5.7	5.7	–
Ploughing [a]	18.8	–	–	–
Wing sweep cultivator [a]	–	9.4	6.7	–
Subsoiling [a]	–	9.4	–	–
Seedbed preparation [c]	6.0	6.0	6.0	
Seeding [b]	2.0	1.9	2.0	2.1
Spreading fertilizer [c]	1.5	1.5	1.5	1.5
Spraying herbicide [c]	2.0	2.0	2.0	4.0
Harvesting [c]	25.0	25.0	25.0	25.0
Transport (5 km) [c]	3.8	3.8	3.8	3.8
Stubble processing [d]	16.8	16.8	16.8	16.8
Total	**81.6**	**81.5**	**69.5**	**53.2**

[a] Szalay et al., 2015; [b] unpublished; [c] ÖKL, 2016; [d] Moitzi et al., 2015

Fertilizer Input rate

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Crop	N	P_2O_5	K_2O
W-Wheat	160 kg (CAN)	-	-
Maize	184 kg (Urea)	-	-
Sugarbeet	97 kg (Urea)	-	-
Rape seed	180 kg (CAN)	-	-

Plant protection:

Herbizid: 3,5 l Glyphosat in NT, crop-specific herbicid

Fungicid: sugarbeet, rape seed and soybean

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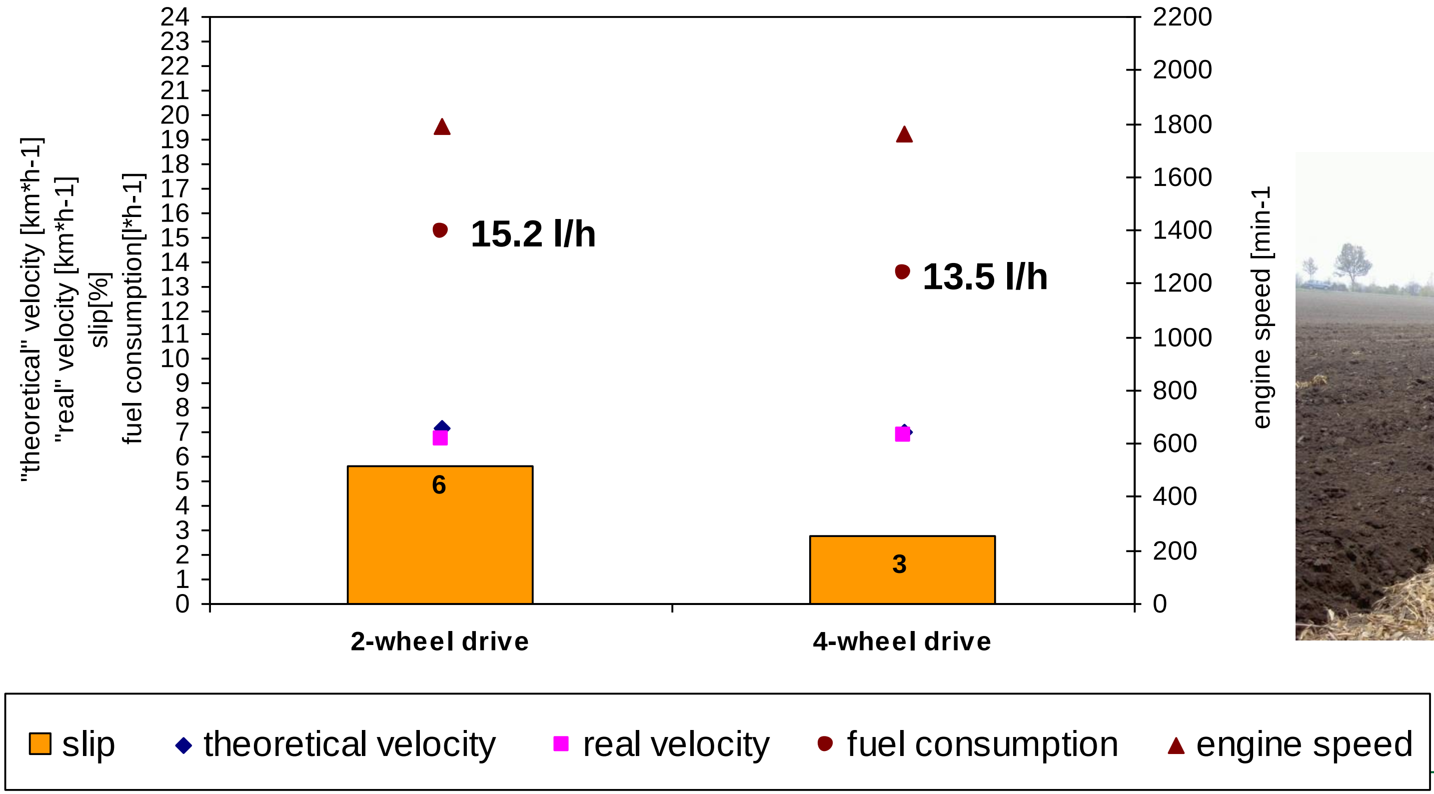
Results: ploughing

(3. gear, 2. power shift); working depth: 15 cm.

Fuel consumption: 13.2 l/ha 11.5 l/ha



Sugar beed seeding with prescion seeder (6th April 2005)

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Tillage processes

- **Stubble processing (stubble field skimming)**: medium tillage (~ 10 cm) after harvesting of the main crop, Incorporation of the plant residues *(practical rule: 1t straw/ha requires at least 1 cm working depth for mixing)*.

- **Primary tillage:** soil tillage at the top soil (-30 cm). Conventional for the main crop.

- **Secondary tillage (**seedbed preparation): Preparing the seedbed for the seeds; Post tillage of the deeper loosened soil at top horizont (level of the mean seeding depth.

- **(Seeding)**

- **Subsoling**: mechanical soil melioration, irregular used depending on crop and subsoil compaction.

„Turbation“-processes (Mixing) of the soil

Bioturbation: through digging soil animals

Hydroturbation (Peloturbation): through water supply and removal in humid climates with clay soils (high amount of swellable clay minerals (montmorillonit), strong shrinkage and swelling processes.

Cryoturbation: result of changes in freezing and thawing in watersaturated soils.

Technoturbation: mechanical soil loosening with technical energy usage

Technology as a service for soil productivity

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„Soil tillage has the task **to support the natural processes** with low input and negative external effects“

Some basic principles for usage soil tillage implements:

⇒ To avoid overloosening

⇒ To prevent soil compaction

⇒ To reduce the contact area pressure between tyre/soil

⇒ To reduce the overrun frequency => combination of implements.

⇒ sustain the natural layers

⇒ To reduce slippage

⇒ To avoid soil erosion

Quelle: H. Pichler, Bildungszentrum Mold der LWK NÖ

Tillage systems defined by Objective

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„conservation tillage“:

The objective of conservation tillage is to provide a means of profitable crop production while minimizing soil erosion caused by wind and/or water. The emphasis is on soil conservation; moisture, energy, labor and even equipment conservation are additional benefits.

⇒ Most commonly defined as any tillage system that maintained at least **30 % residue** cover on the soil surface after planting to reduce water erosion.

⇒ Represents a broad spectrum of tillage implements and planting systems

3 Subsystemes:

Mulch-till

Ridge-till

No-till

"Ridge tillage"

Beds, ridges, hills or mounds are commonly used in vegetable crop production, particularly root crops.

There is a wide variety of designs for these surface features, each specific to the crop (e.g. potatoes) and the management practice (planting or hilling potatoes).

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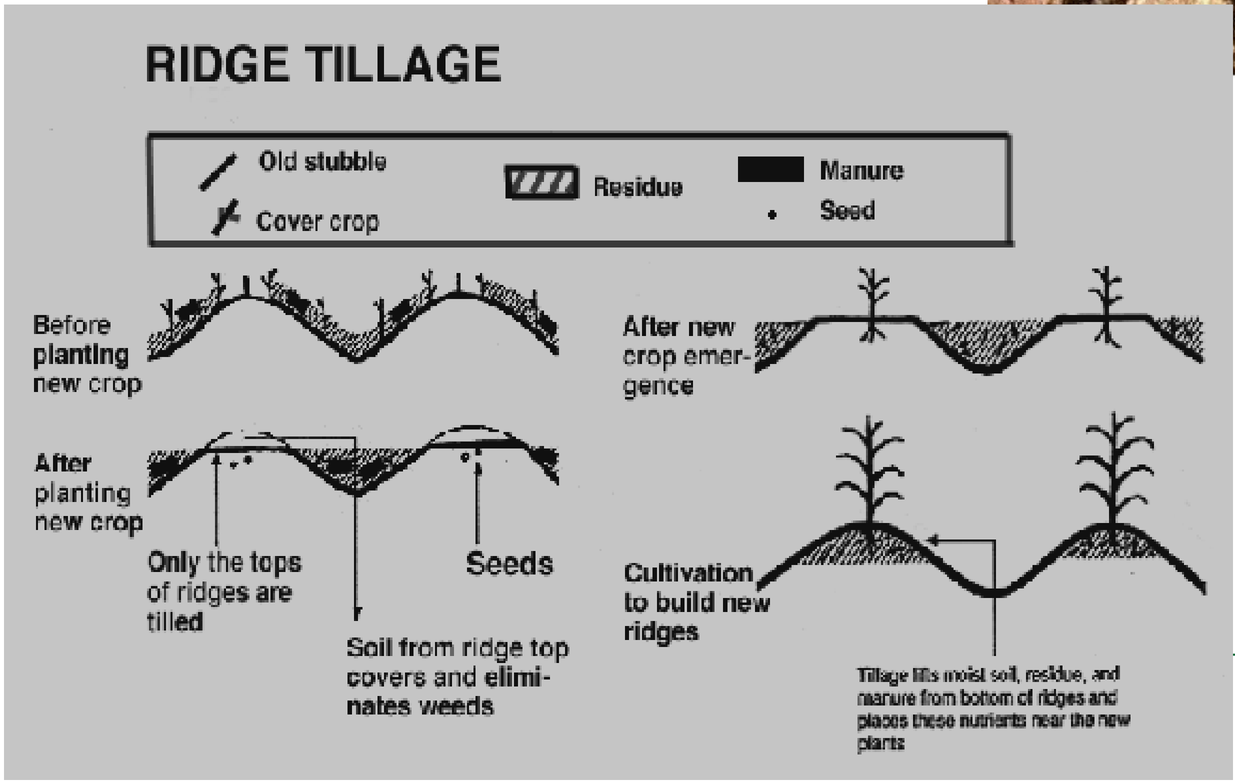
Source: Lobb (2011); Manitoba, Canada

Ridge Tillage as a soil conservation system

Ridge-Till



Source: Lobb (2011); Manitoba, Canada

Conserving Surface Water:

Furrow-diker / Dammer-diker

Source: Lobb (2011); Manitoba, Canada

No-till (Zero-till, Slot-plant):

… the soil is left undisturbed from harvesting to seeding

and from seeding to harvest.

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The only „tillage" is the soil disturbance in a **narrow slot**, created by coulters, disk or runner seed furrow openers, or hoe openers attachted to the planter drill.

Soil tillage systems (terms are used in scientific literature):

Low disturbance seeding with narrow openers
High disturbance seeding with sweeps

Effects of working depth for energy consumption

1 cm deeper ploughing:

- An additional soil movement **of 100 m^3 or 150 t/ha**
- An additional fuel consumption between 0.5 and 1.5 l/ha
- An additional fossil CO_2-emission till 4.0 kg/ha

Influence of different fertilization on fuel consumption in ploughing.

Quelle: McLaughlin et al. Effect of organic and inorganic soil nitrogen amendments on mouldboard plow draft; Soil & Tillage Research, 2002

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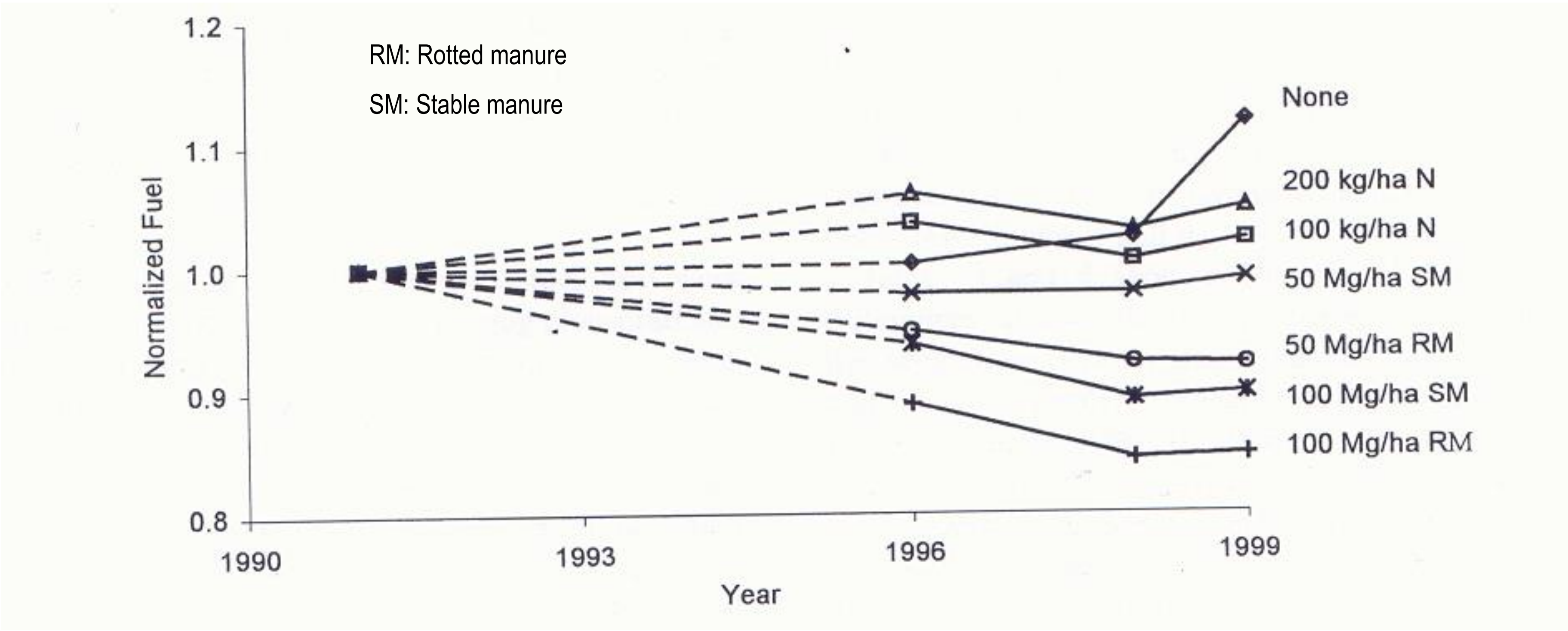

CO_2-Emissionen from soil through mineralisation

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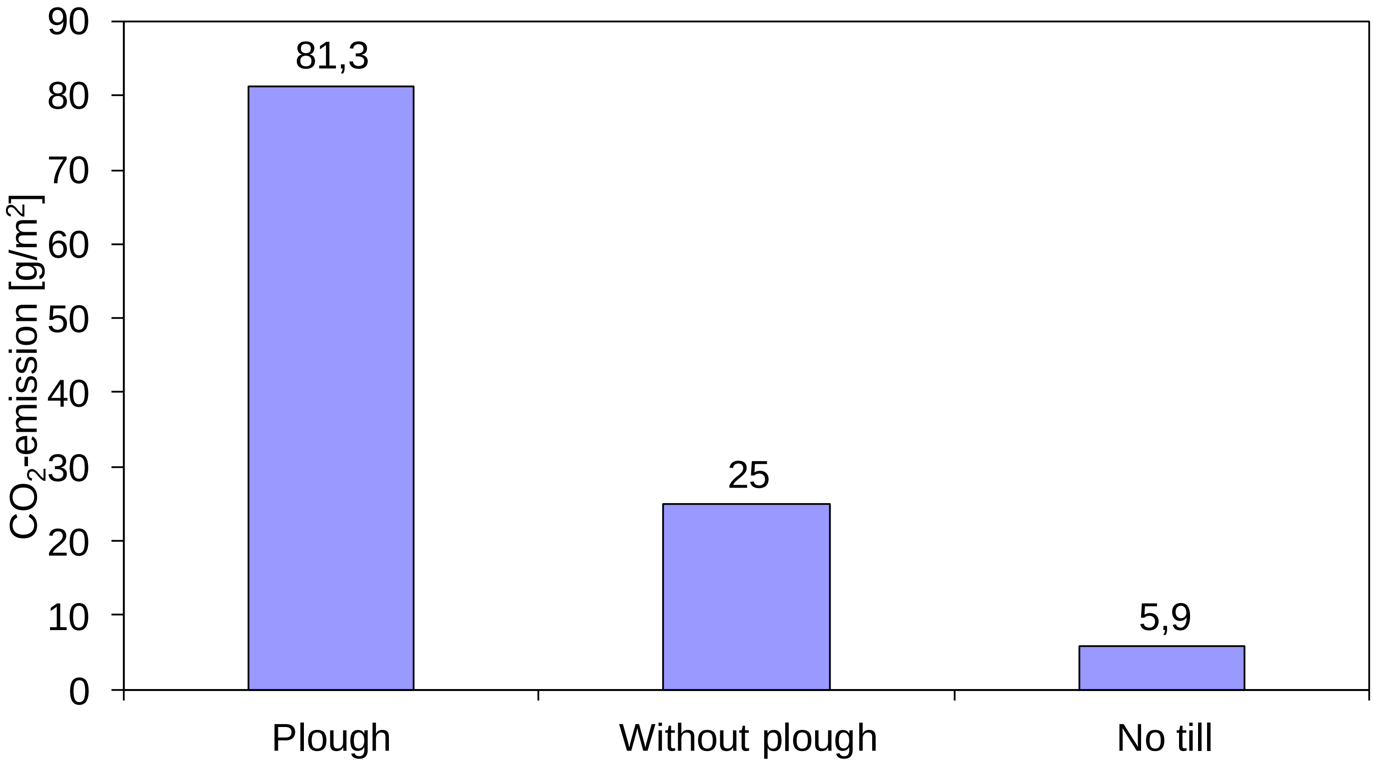
Cumulative CO_2-emissions within 5 hours after tillage



Quelle: Reikosky, D. C.: Tillage intensity and CO_2 emission from soils. Proceedings of the 14th ISTRO-Conference, Pulawy/Poland 1997. S. 555-558.

Soil structure diagnosis with spade

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Tschernosem-Parabraunerde aus Löß

Bildquelle: Horn, 2005

Re-compaction of an overloosened soil:

Effect on rooting

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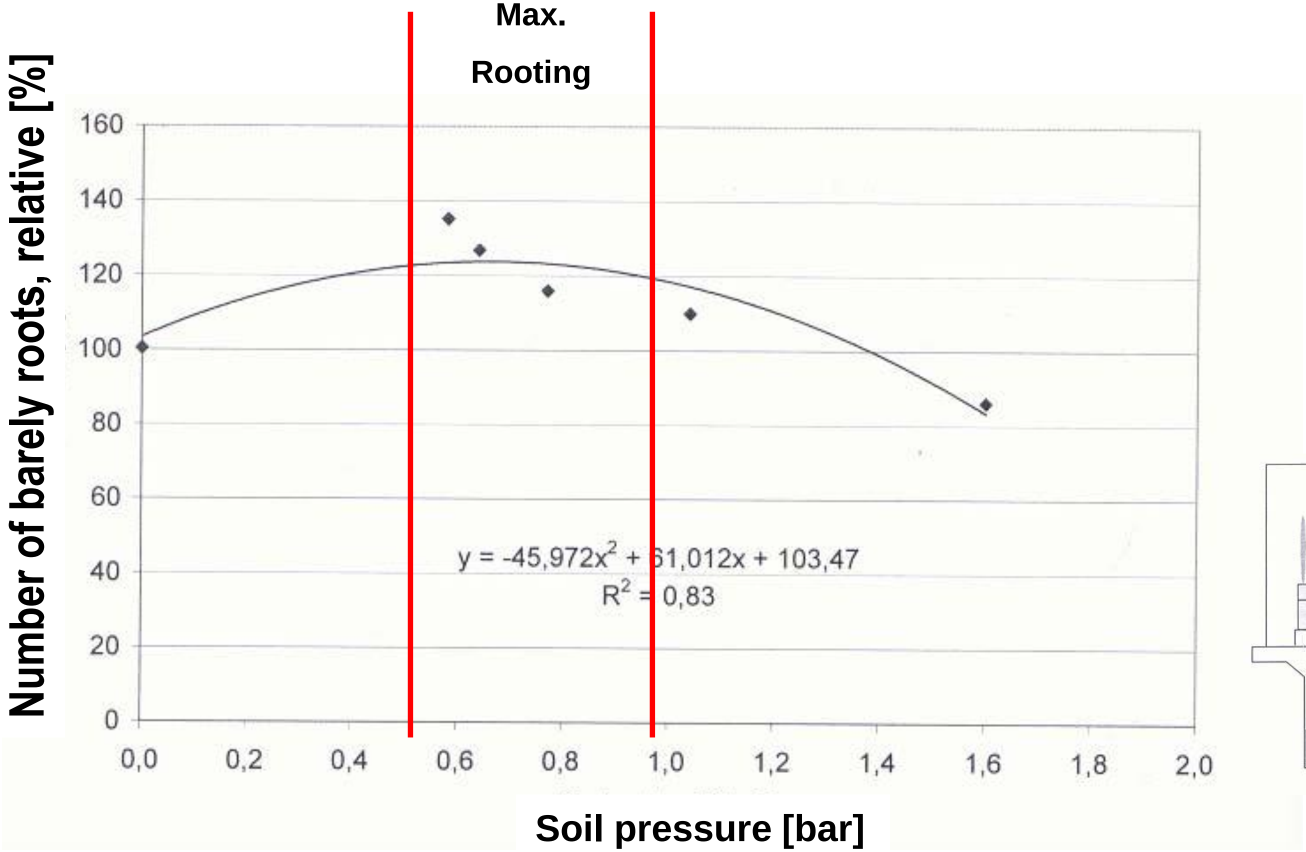

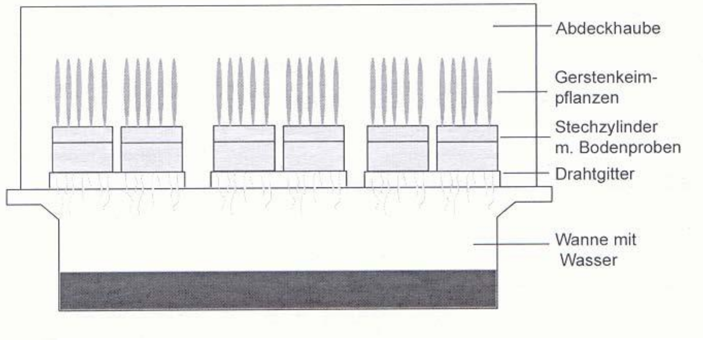

Bildquelle: Weißbach 2003

Quantity of rooting in a soil: Number of radicle (dt. Keimwurzel) of barley

Soil: loamy sand

Soil erosion,
- original promoter for development of conservation tillage

Erdsturm am 21. Februar 2004,

auf der B-6 vor Laa/Thaya,

1930s:

Extreme wind erosions in the intensive cereal cropping areas in the Great Plains (USA)

Main reasons for plough-abandonment (Köller & Linke, 2001):

1. Reduction of soil erosion
2. Work time and cost saving
3. Increase of field performance and labour productivity
4. Avoidance of damages in the soil structure

Average soil erosion in Austria: ∅ **7 t soil/year/ha**

Main Reasons:

=> Steepness of many fields

=> High loess-content in flat areas.

1 mm soil/ha = 15 t soil

(bulk density: 1,5 g/cm^3)

Gully erosion

© Monika Frielinghaus

27. Mai 2013, Petzenkirchen

Conservation Agriculture (CA)

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Conservation agriculture (CA) aims to achieve sustainable and profitable agriculture and subsequently aimes at improved livelihoods of farmers through the application of the three CA principles: **minimal soil disturbance, permanent soil cover and crop rotations**. CA holds tremendous potential for all sizes of farms and agro-ecological systems, but its adoption is perhaps most urgently required by smallholder farmers, especially those facing acute labour shortages. It is a way to combine profitable agricultural production with environmental concerns and sustainability and it has been proven to work in a variety of agroecological zones and farming systems. It is been perceived by practitioners as a valid tool for Sustainable Land Management (SLM).

It is because of this promise that FAO is actively involved in promoting CA, especially in developing and emerging economies. CA can only work optimally if the different technical areas are considered simultaneously in an integrated way. Therefore staff from several Divisions of FAO took the initiative to create an informal workgroup consisting of members from the Plant Production and Protection Division (AGP), the Land and Water Division (NRL), and Rural Infrastructure and Agro-Industries Division (AGS). It is understood that the multidisciplinary nature of CA will always require the rich mix of expertise available to FAO as it works to promote the CA concept worldwide.

http://www.fao.org/ag/ca/

Key technology for CA

- Direct seeding – not till

- Management of cover/catch crops e.g. with balde roller

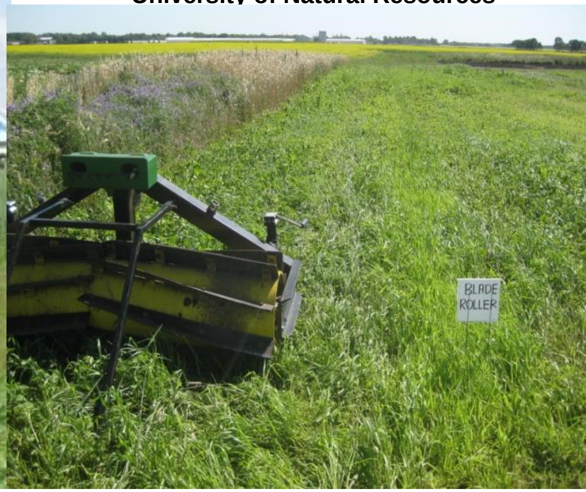
- Avoidance of soil compaction in the cropping area through permanent tracks (Controlled-Traffic-Farming - CTF)

Quelle: Flur und Furche, September 2007

Management of Cover crops

University of Natural Resources

Blade roller



Flail mower

Conservation Agriculture (CA)

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Conservation Agriculture (CA)

Bildquelle: Friedrich FAO; 2007

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Effects of Conservation Agriculture

Quelle: Friedrich FAO; 2007

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on soil:

⇒ soil build up: app. 1 mm soil/ year
⇒ Increase of soil organic matter: app. 0,1 - 0,2% /year till steady-state balance
⇒ Different root systems of different plant species for better nutrient efficiency
⇒ Solid soil structure
⇒ Reduction of soil erosion and degradation

on water

⇒ Refill of the groundwater (permanent macro-pores, „bypass-flow“)
⇒ Better water-quality (less nutrient leaching)
⇒ Higher plant available water content asser (1 % OM = 150 m^3/ha)
⇒ better water-use efficiency

Rooting of mixted plants (cover crops)

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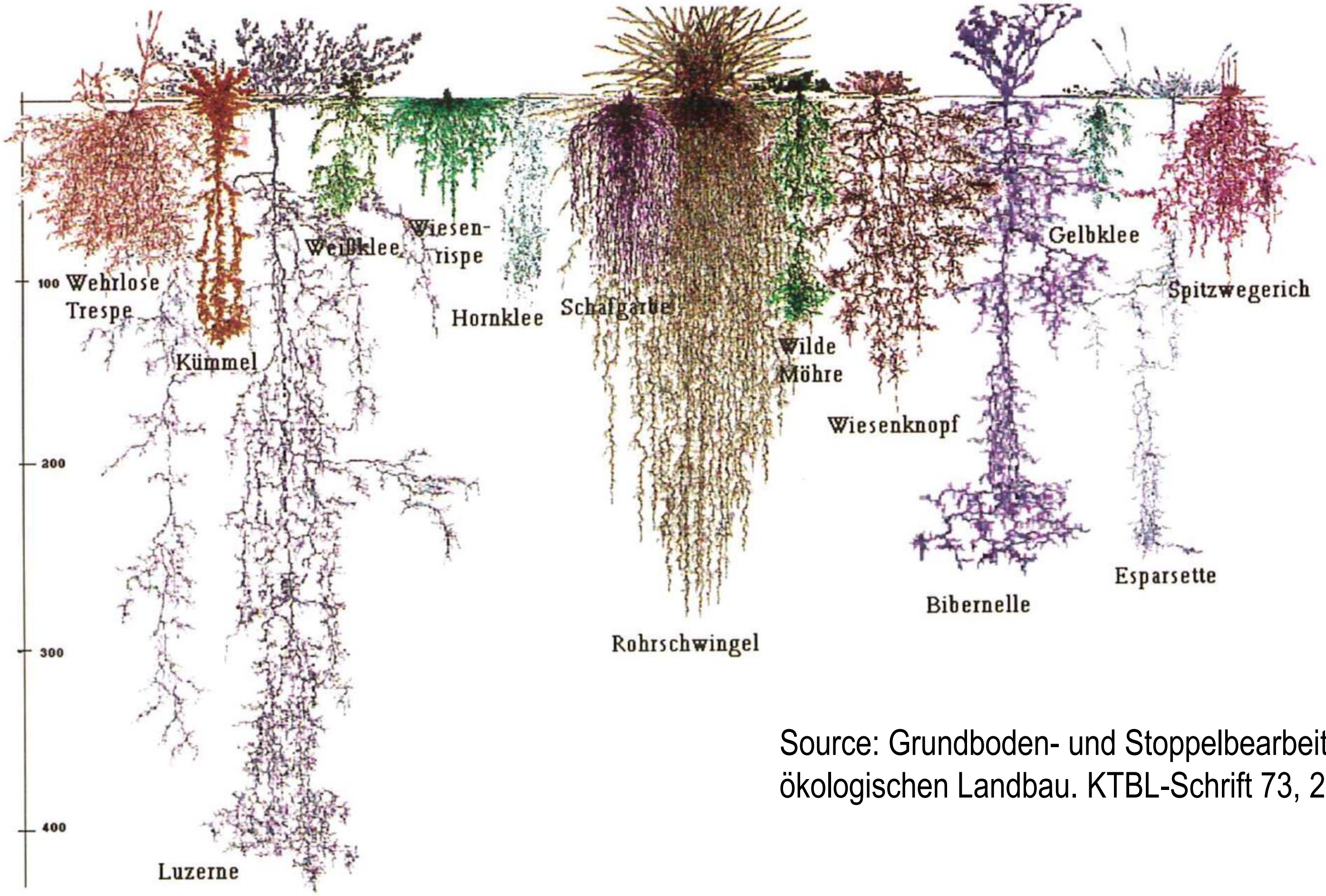
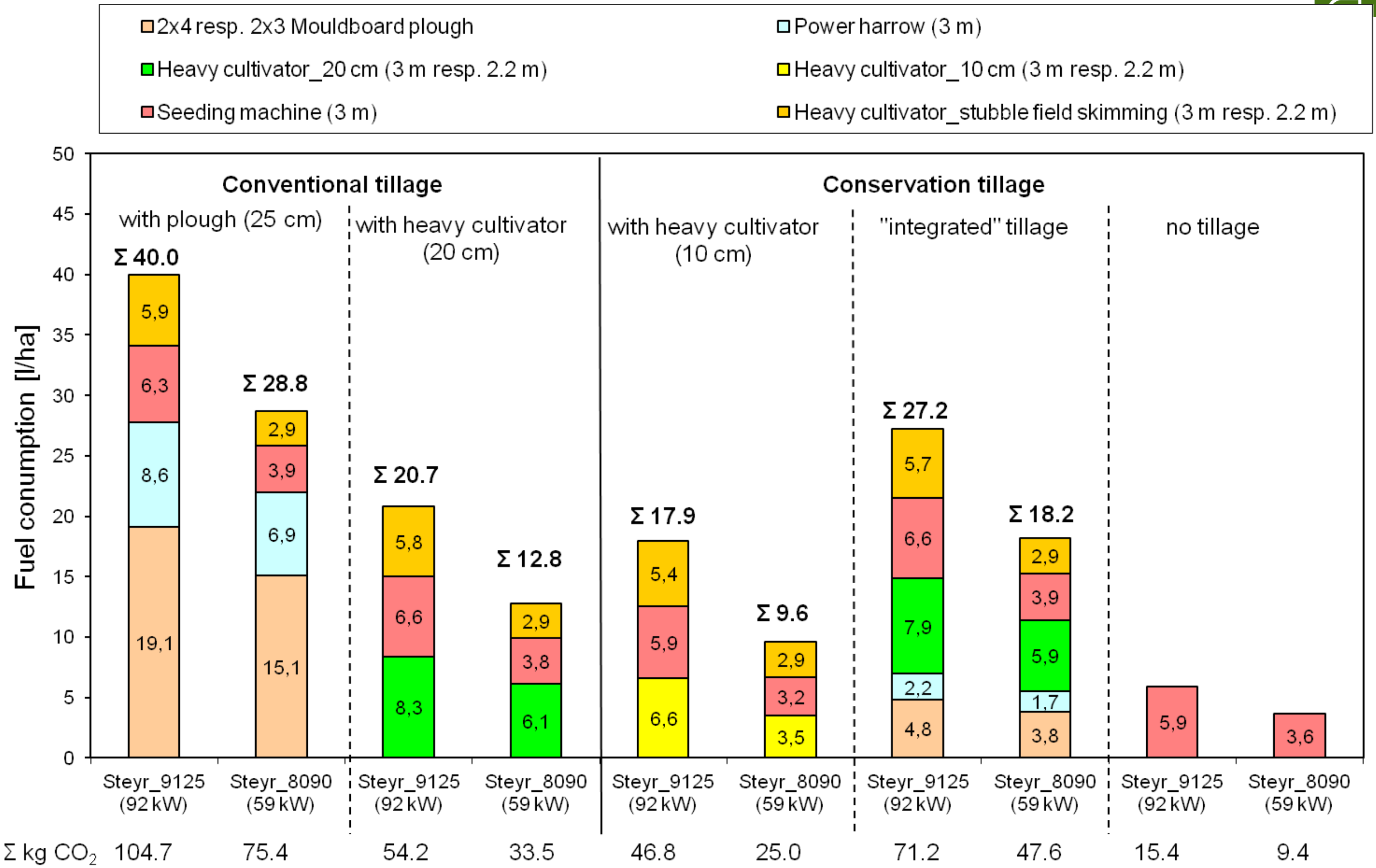


Source: Grundboden- und Stoppelbearbeitung im ökologischen Landbau. KTBL-Schrift 73, 2007

Abb. 29: Durchwurzelung des Bodenraums durch Mischkultur (BRAUN nach KUTSCHERA 1960, KUTSCHERA und LICHTENEGGER 1982 und KUTSCHERA und LICHTENEGGER 1992)

Fuel consumption in different tillage systems and mechanisation



The average fuel consumption with CO_2-emission for different tillage processes in dependence of mechanization and soil tillage system.

A mouldboard plough instead of a cultivator is used every four years in the "integrated" tillage system.

Experimental-station of the University of Natural Resources and Life Science (BOKU) in Groß-Enzersdorf; average temperature: 9.8 °C; precipitation: 546 mm; silty loam of Chernozem

Experimental Farm Groß-Enzersdorf

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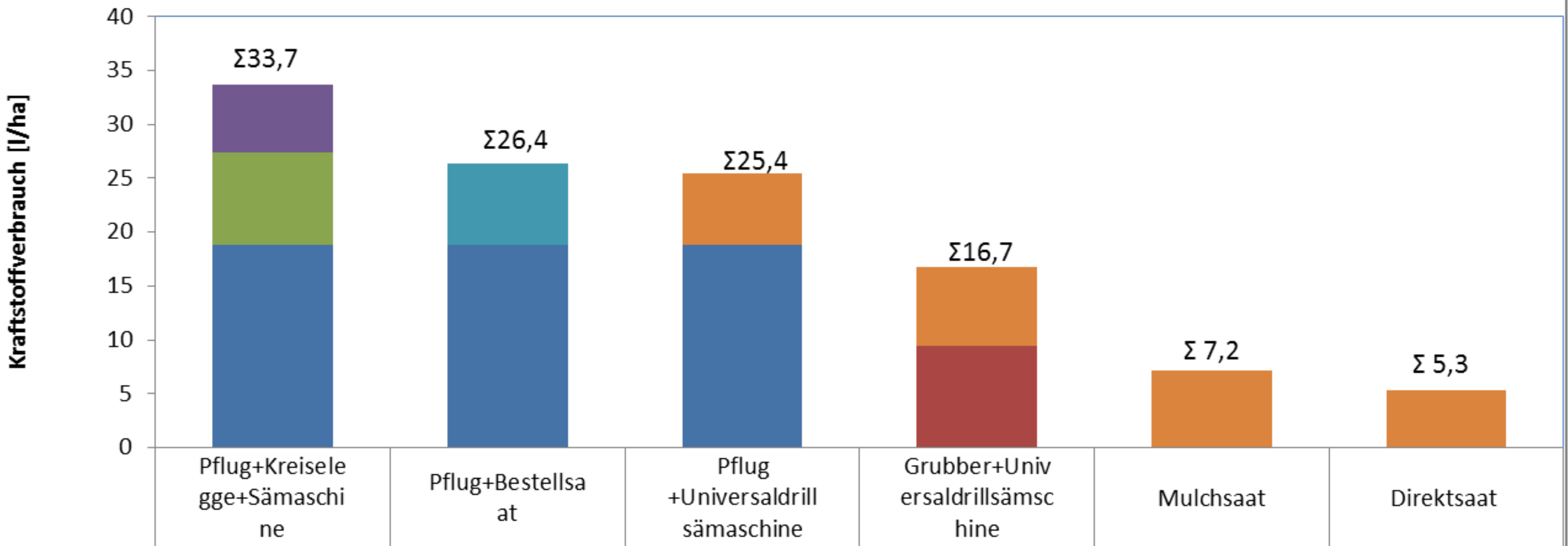
Kraftstoffverbrauch bei der Bodenbearbeitung und Aussaat mit unterschiedlicher Mechanisierung



	Pflug+Kreiselegge+Sämaschine	Pflug+Bestellsaat	Pflug +Universaldrillsämaschine	Grubber+Universaldrillsämschine	Mulchsaat	Direktsaat
Universaldrillsämaschine (pneu.)			6,6	7,3	7,2	5,3
Bestellsaat (Kreiselegge-Sämaschine)		7,6				
Drillsämaschine (mech.)	6,3					
Kreiselegge	8,6					
Grubber (3 m, Flügelschar)				9,4		
Pflug (4 -Scharvolldrehpflug)	18,8	18,8	18,8			

Kraftstoffverbrauch bei der Aussaat mit einer pneumatischen Universaldrillmaschine

bei unterschiedlicher Bodenvorbereitung (unbearbeitet, gegrubbert, gepflügt)-
+VW: Vorwerkzeuge (Kurzscheibenegge) abgesenkt, -VW: Vorwerkzeuge (Kurzscheibenegge) hoch gehoben. v=11 km/h

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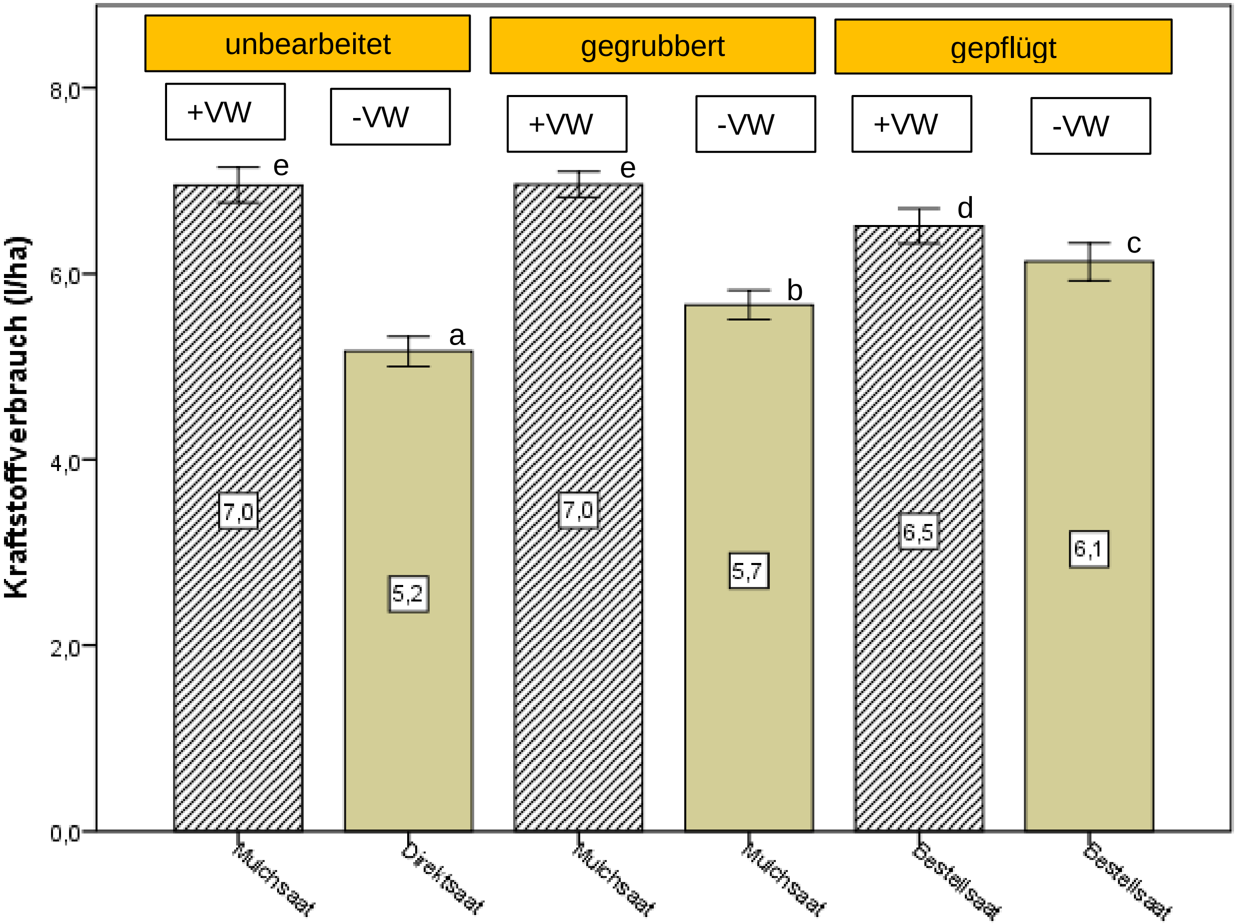
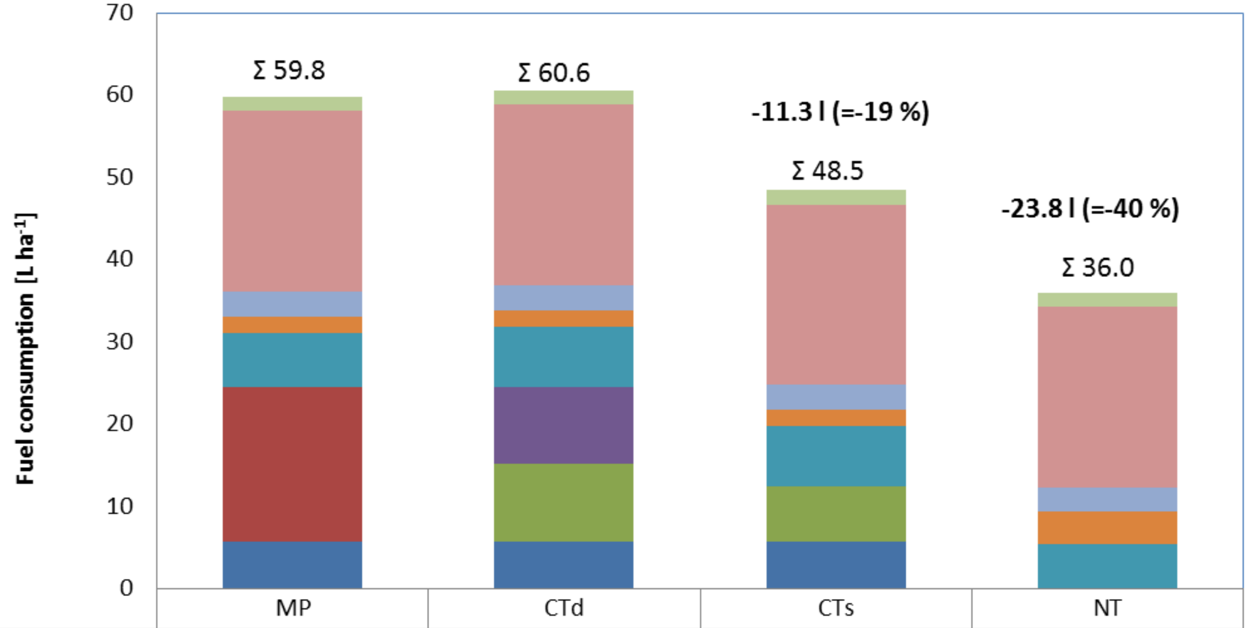


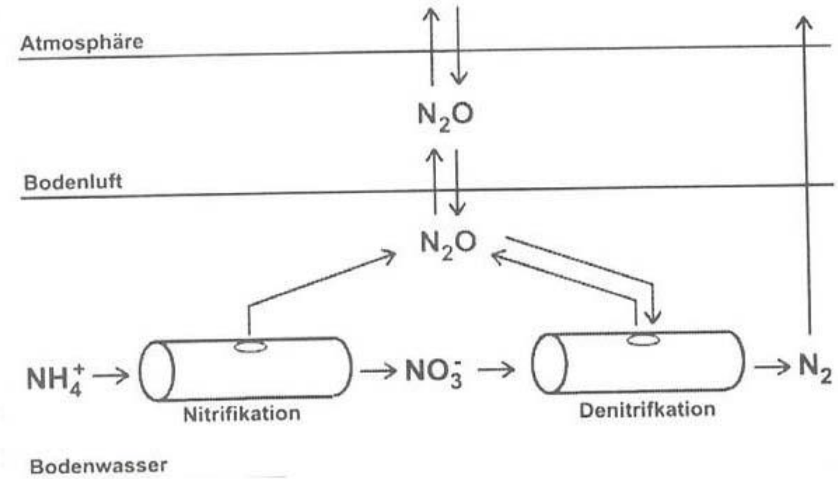
[*] **unterschiedliche Buchstaben kennzeichnen statistisch signifikanten Unterschiede: Student-Newman-Keuls-Test bei α=0,05.**

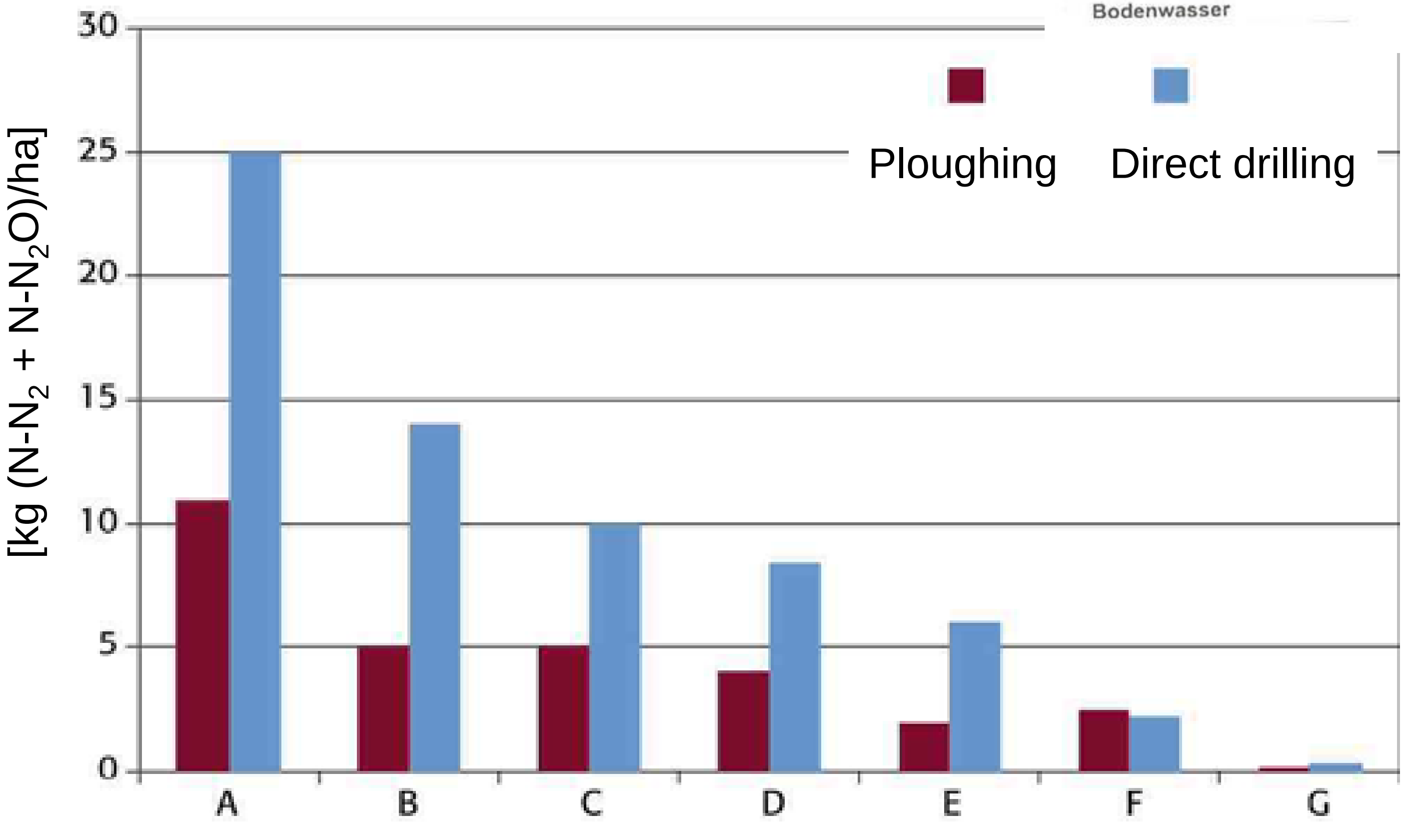
Fuel consumption for winter wheat in different tillage systems



	MP	CTd	CTs	NT
Transport (5 km)	1,7	1,8	1,8	1,7
Combine harvester	22	22	22	22
Spreader	3	3	3	3
Sprayer	2	2	2	4
Pneumatic universal seed drill	6,6	7,3	7,3	5,3
Subsoiler		9,4		
Wing share cultivator		9,4	6,7	
Mouldboard plough	18,8			
Wing share cultivator (Stubble cultivation)	5,7	5,7	5,7	

Nitrogen loss through denitrification





Source:

Selceted Papers form ARVALIS - Institut du végétal; May 2009 Nr. 8

Various foreign references (direct measurement in field or on columns of soil)

Comparison of Tillage systems

University of Natural Resources and Life Sciences, Vienna
Department of Crop Sciences

	Conventional tillage (with plough)	Conservation tillage (without plough)	
	Pflugsystem	Mulchsaatsystem	Direktsaatsystem
	Faktoren, welche die Saattechnik direkt beeinflussen		
Tillage intensity	wendend, intensiv	nicht-wendend	mind. 50% des Bodens unbearbeitet
Soil covering	keine	mittel	viel
Necessary share pressure	gering	mittel	hoch, je nach Bauart
Share type	Shoe opener	Disc opener	Disc or chisel opener
Straw management	Not so important	important	Very important
Mechanical weeding At seeding	Very good - plough	partial	no
	Faktoren, welche durch das Anbausystem beeinflusst werden		
Working time and fue consumotion for tillage and seeding	high	medium	small
Earthworms	nehmen mit abnehmender Bodenbearbeitung meist deutlich zu		

Quelle: Agroscope Reckenholz-Tänikon ART, 2007

Effect of long-term applied tillage systems on organic matter contents in soil, expressed by the content of organic carbon in the top soil of the Eutric Cambisol (according to Grocholl, 1991).

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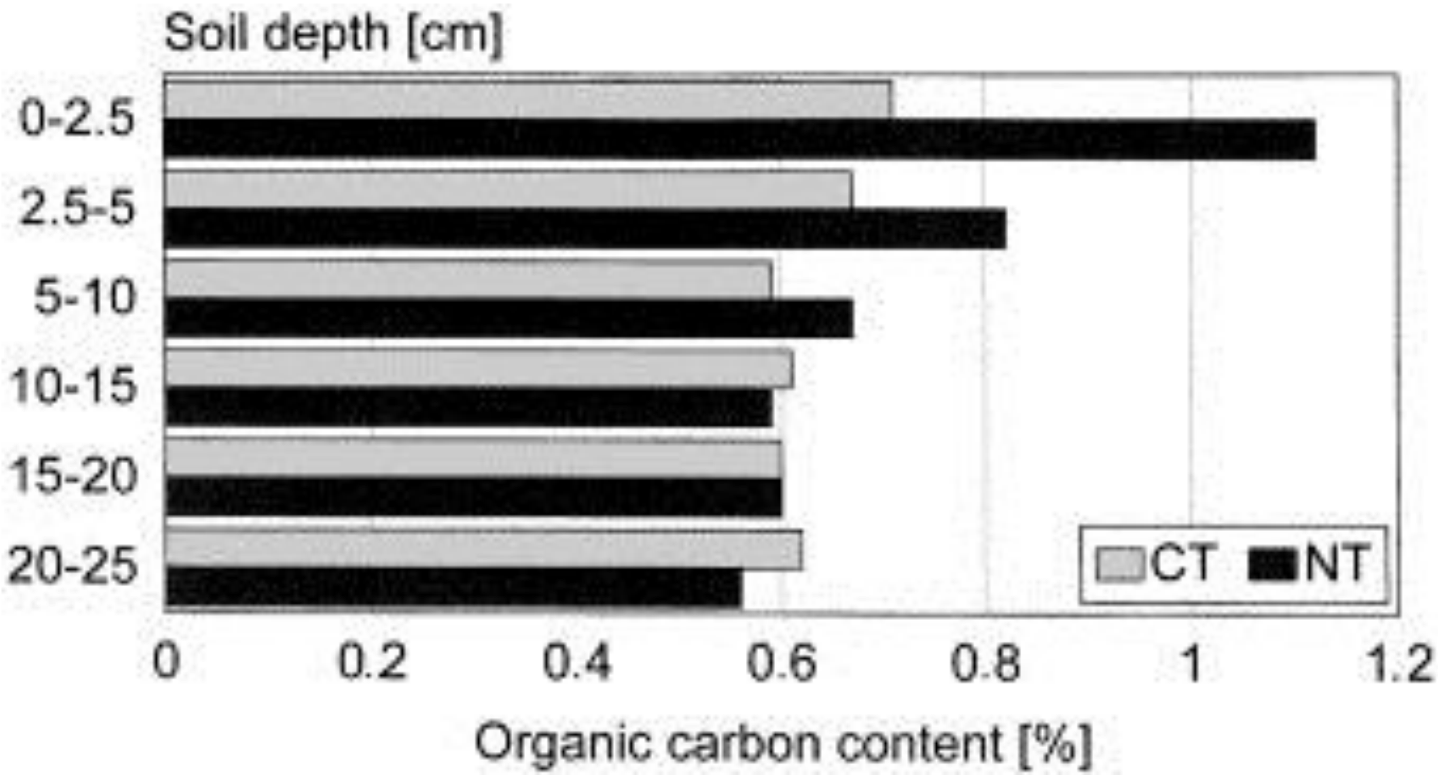

Tebrügge, F. & R-A Düring (1999): Reducing tillage intensity – a review of results from a long-termin study in Germany. Soil and Tillage Research Nov. 1999, papes 15-28

Applied tillage systems and their effects on performance and requirements. Impact on soil depth and soil surface

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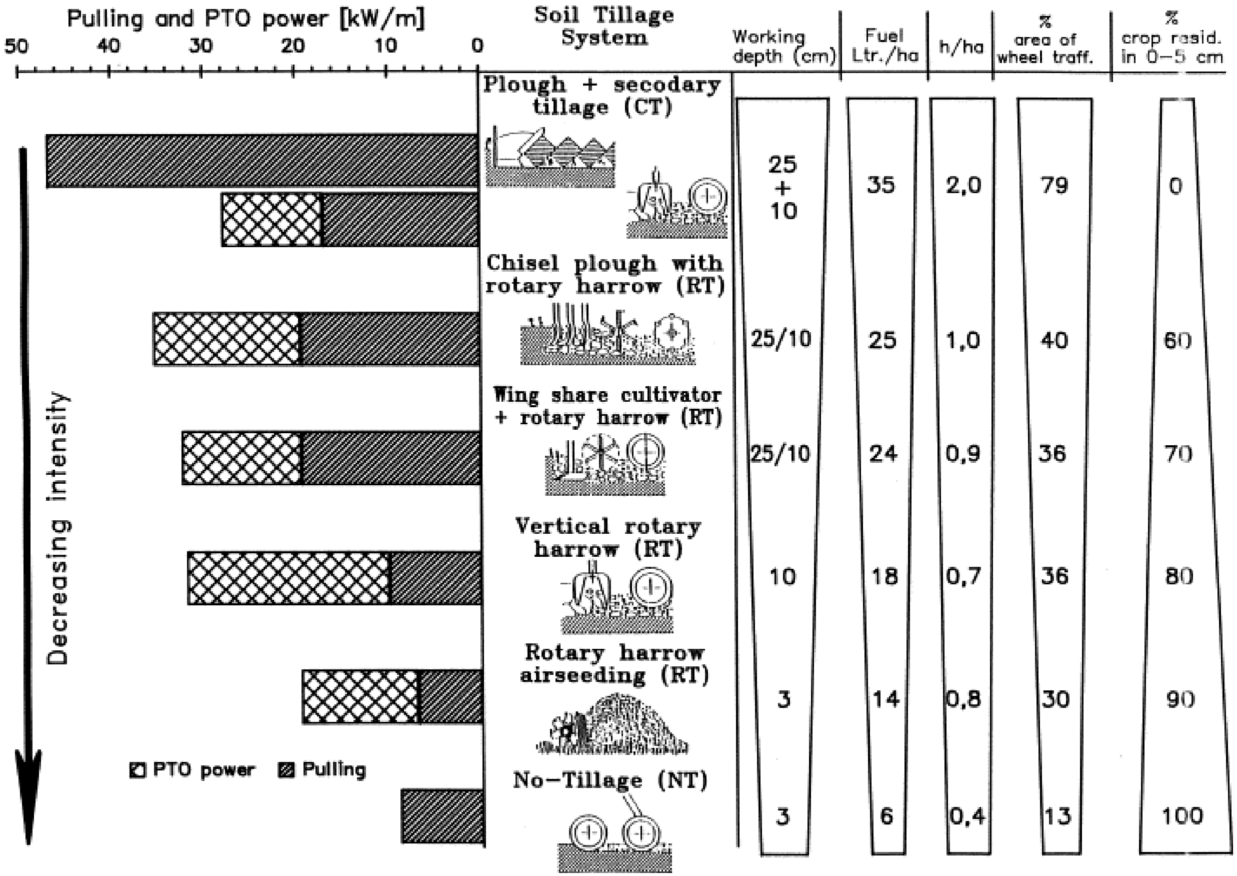

Tebrügge, F. & R-A Düring (1999): Reducing tillage intensity – a review of results from a long-termin study in Germany. Soil and Tillage Research Nov. 1999, papes 15-28

Degree of incorporation of straw [%] in the soil horizon as affected by soil tillage systems (Schmidt and Tebrügge, 1989)

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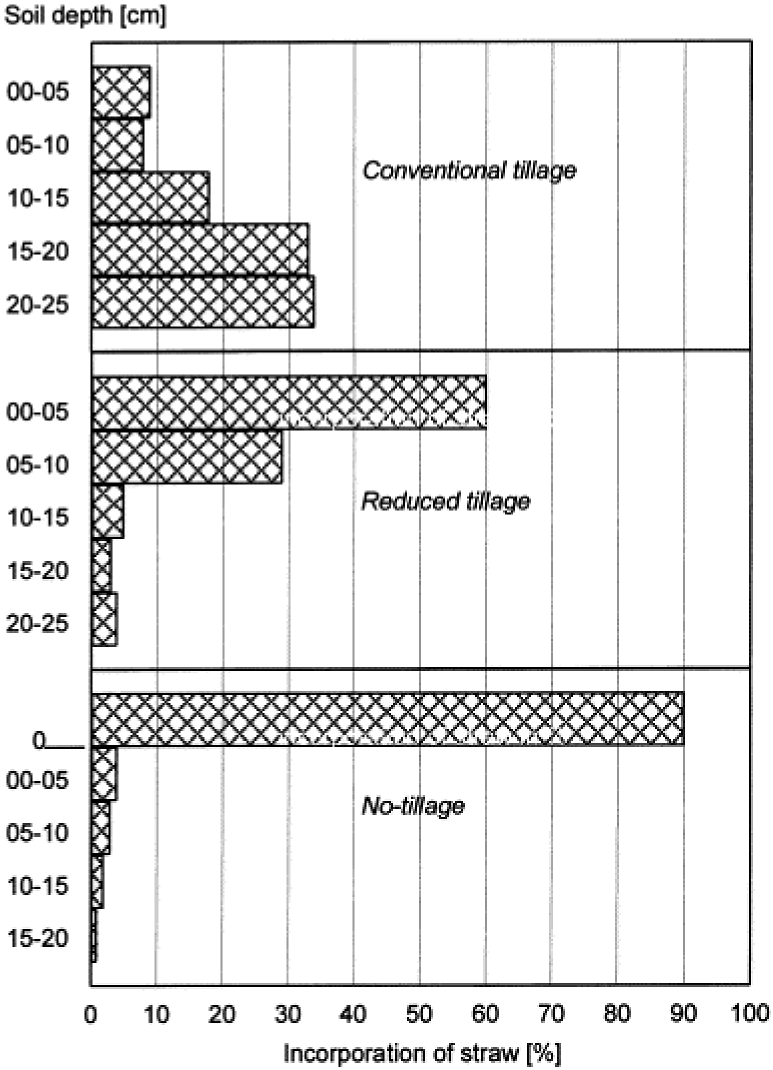

Tebrügge, F. & R-A Düring (1999): Reducing tillage intensity – a review of results from a long-termin study in Germany. Soil and Tillage Research Nov. 1999, papes 15-28

Penetration resistance, water content, and bulk density in soil dependent on tillage intensity and soil depth — Luvic Phaeozem

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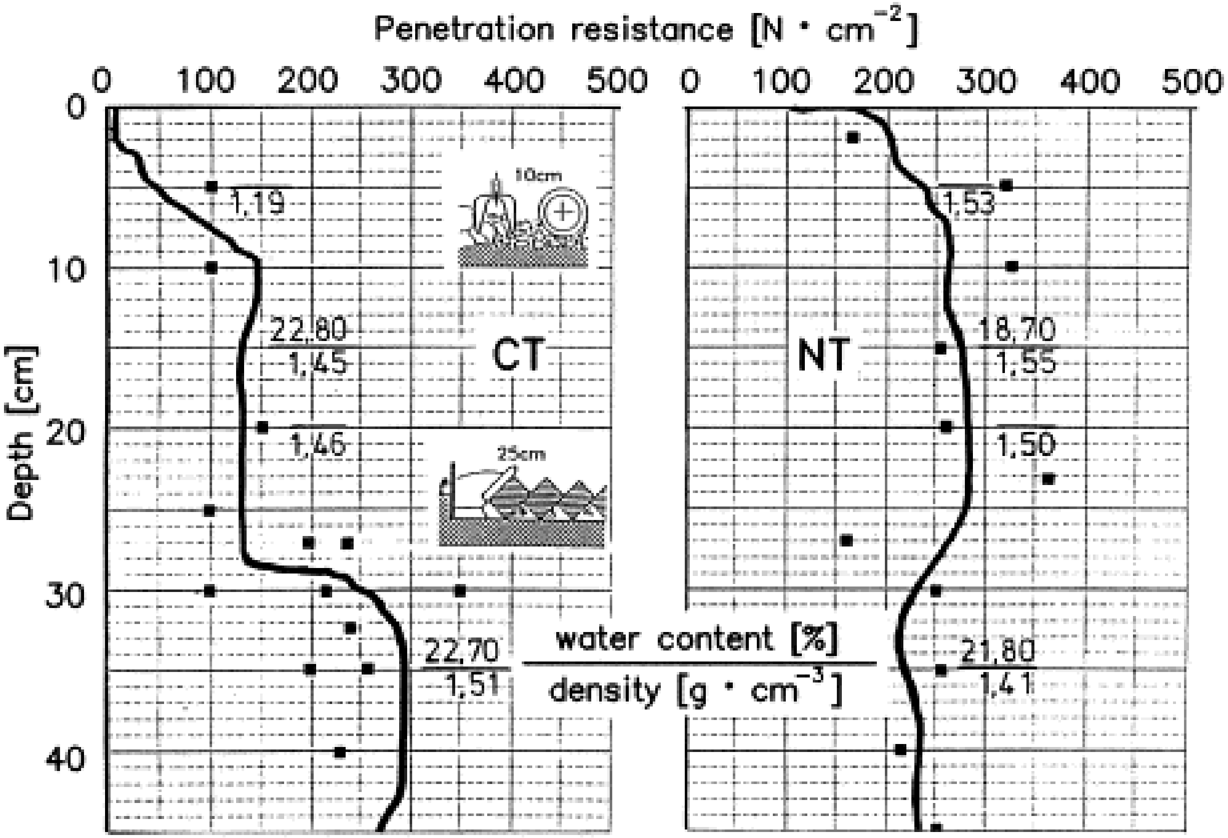

Tebrügge, F. & R-A Düring (1999): Reducing tillage intensity – a review of results from a long-termin study in Germany. Soil and Tillage Research Nov. 1999, papes 15-28

Pore size distribution (as percentage of soil volume) in different depths at different times of conventionally (CT) and non-tilled soil — Eutric Fluvisol

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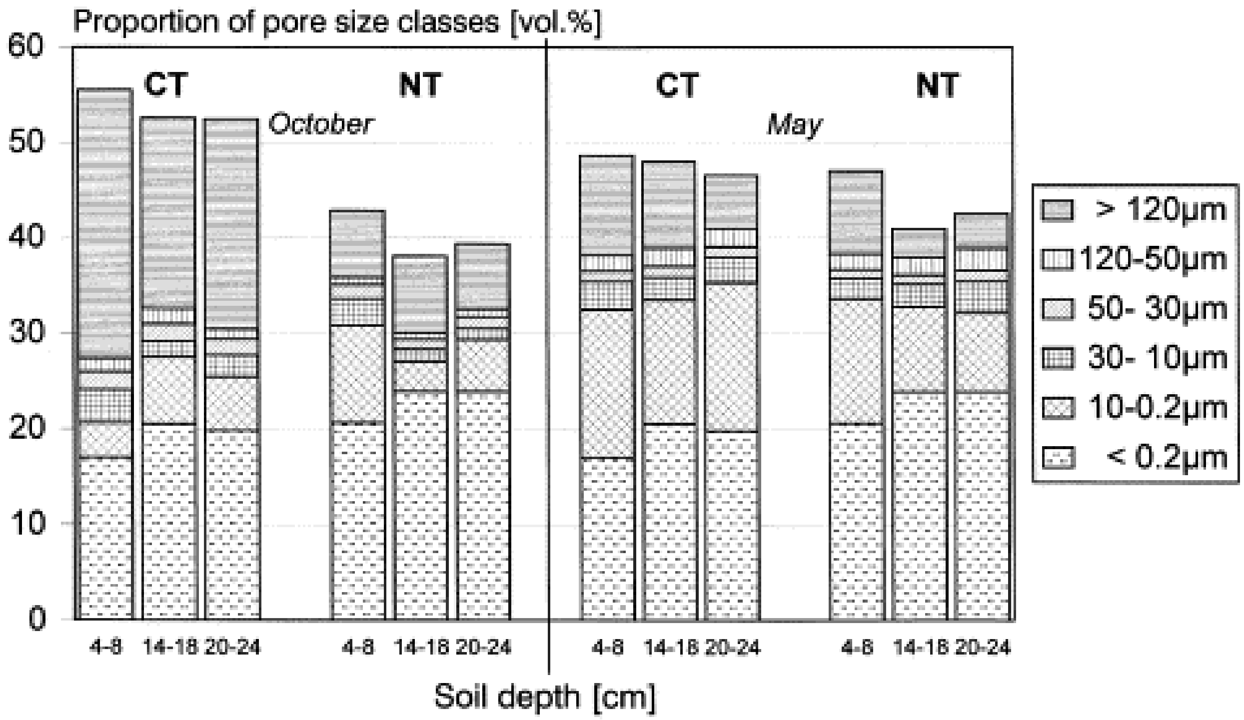

Tebrügge, F. & R-A Düring (1999): Reducing tillage intensity – a review of results from a long-termin study in Germany. Soil and Tillage Research No 1999, papes 15-28

Pore size distribution before and after traffic in CT and NT soils (Luvic Phaeozem). Significant differences (0.05 level) are marked by *. Pore size expressed as percent of soil volume

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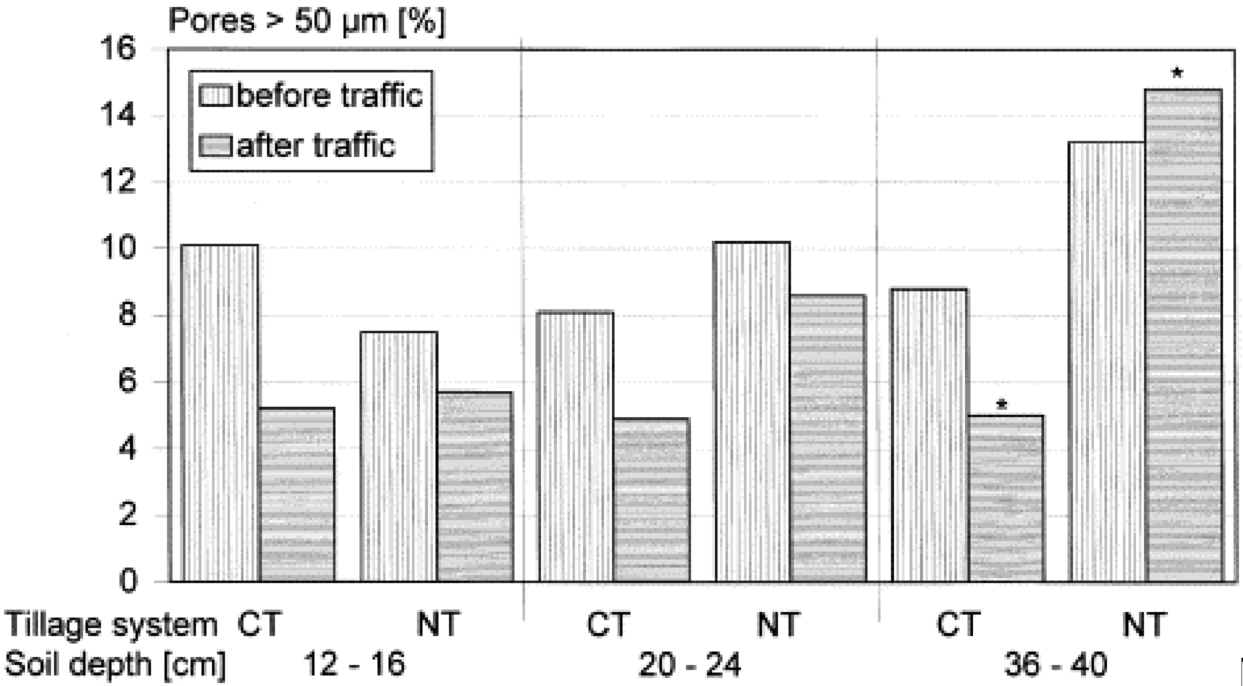

Tebrügge, F. & R-A Düring (1999): Reducing tillage intensity – a review of results from a long-termin study in Germany. Soil and Tillage Research No 1999, papes 15-28

Influence of different soil preparations and vehicle speed on process parameters at seeding of peas (*Pisum sativum*) with a trailed pneumatic universal seed drill

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Department of Crop Sciences

G. Moitzi, K. Schulmeister, C. Aschauer, H. Wagentristl, A. Gronauer

41st International Symposium „Actual Tasks on Agricultural Engineering"

19th -22nd February 2013, Opatija, Croatia

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Site-related factors (climate, soil)

**Energy efficiency
in plant production**

Input of farm facilities (seeds, fertilizer, pesticide, etc.)

Mechanization (e.g. soil tillage)

Classification of soil tillage systems according intensity and soil covering

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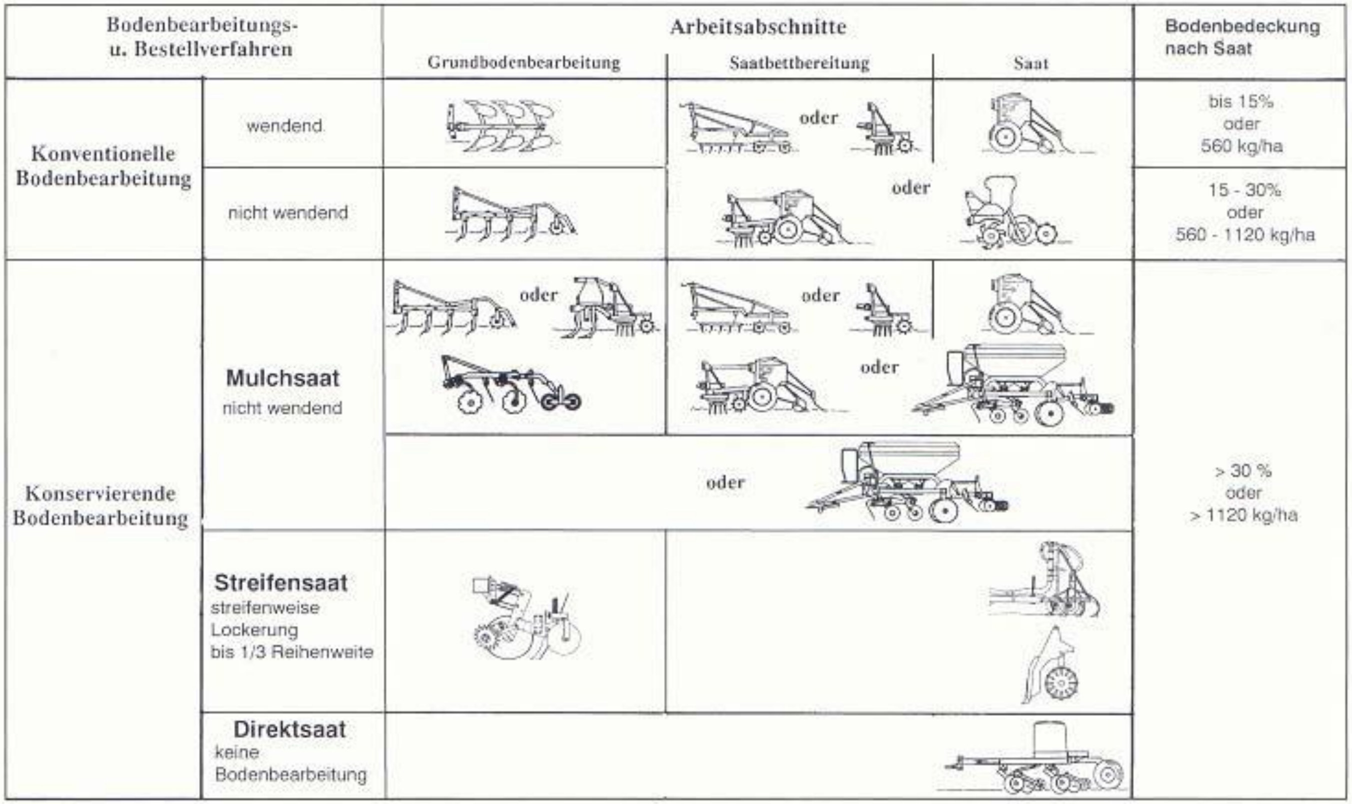

Bild 2: Einteilung der Bodenbearbeitungsverfahren

Nach Loibl & Köller (**Landtechnik Sonderheft 2006**)

Fuel consumption in soil tillage

- **Soil tillage can be an large energy consumer:**
  => 1 cm soil tillaged → approx. 100 m^3 or 150 t/ha must be moved
  => per 1 cm ploughing depth → **0.5 – 1.5l/ha**

- Transmission of drawbar power via the interface wheel and soil surface is affected by the efficiency of traction:

Onland-ploughing

tractor-releated factors:

weight, number of driven axle, kind of tyre, inflation pressure etc.

soil-releated factors:

surface hardness, soil moisture content etc.

Efficiency of traction

Experimental farm of BOKU in Gross Enzersdorf (Lower Austria)

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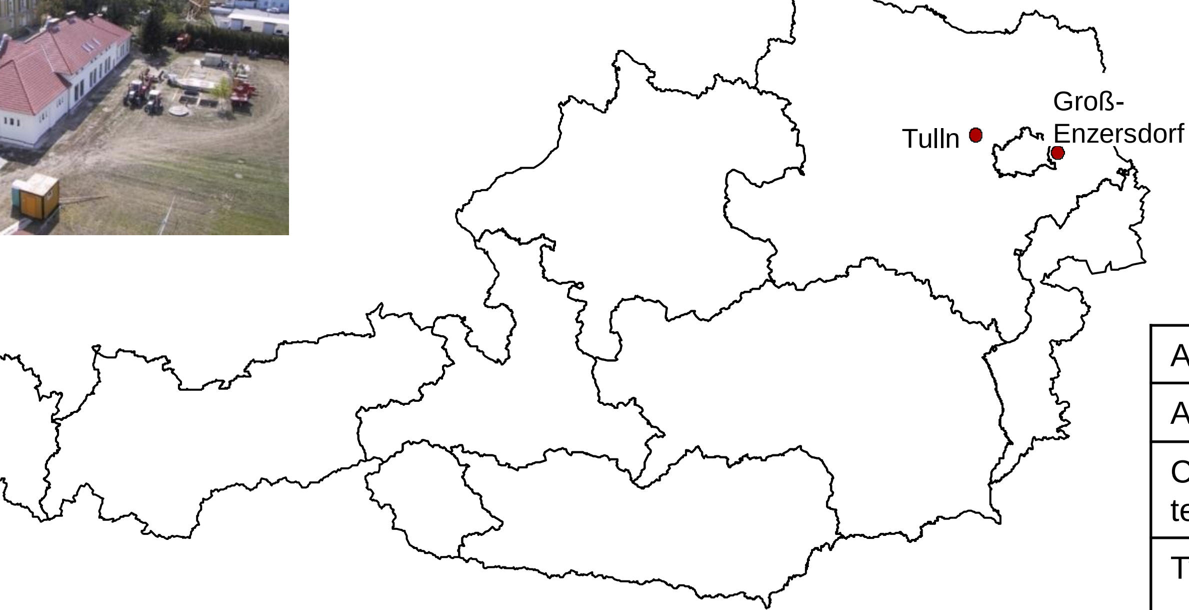

Average temperature	9.5 °C – 10 °C
Average rainfall	500 – 600 mm
Classification of soil texture	loamy clay
Type of soil	Gleyc Chernozem And pure Chernozem

Experimental Farm Groß-Enzersdorf

Technical specification

Double Disc Coulter

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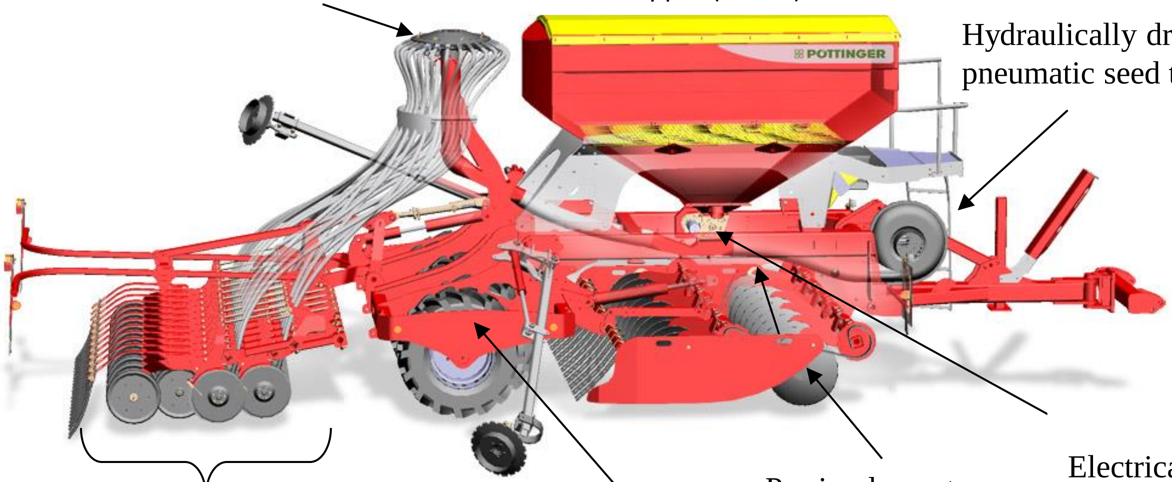
Distributor head with 24 outleds for the seed pipes

Seed hopper (3000 l)

Hydraulically driven fan for pneumatic seed transport



24 Double Disc Coulter in offset adjustment with pressure roller and central coulter-pressure adjustment (40 -120 kg).

Combined Packer/ Chassis unit

Pre-implement frame with Short Disc Harrow (SDH)

Electrical dosage drive, controlled via radar-sensor

Working width	3 m
Power demand	110 PS
Number of rows	24 Double Disc Coulter
Disc coulter diameter	380 mm
Tyre	425/55R17
Weight	4550 kg
Coupling to tractor	Via steel base plate to lower linkage of the three point linkage system
Operating	ISOBUS –compatible or operating terminal (ARTIS)
Dosage-system	Electrical, continuously seed amoung adjustment from 0,6 kg bis 350 kg

Influence of different soil preparation and vehicle speed on process parameters at seeding of peas with an trailed pneumatic universal seed drill

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Investigation treatments

	Universal-seed dríll **Without** pre-implement	Universal-seed drill **With** pre-implement
Untreated stubble	8, 10, 11 km/h; je 4 replicates	8, 10, 11 km/h; je 3 replicates
Cultivated (15 cm)	8, 10, 11 km/h; je 4 replicates	8, 10, 11 km/h; je 3 replicates
Ploughed (20 cm)	8, 10, 11 km/h; je 3 replicates	8, 10, 11 km/h; je 4 replicates

Methods and experimental procedure

- Integration of the flow meter (*PLU 116 H* into the fuel systems of traktor Steyr 9125 a (92 kW)
- Measuring of the vehicle speed with the radar sensor and theoretical speed with the transmission sensor as well as the engine speed continouosly
- Scan-frequency of the dataloggerr *Squirrel*: 1 Hz
- Investigation area (450x63m) in Raasdorf (Lower Austria)
- Soil: silty loam
- Soil preparation: plowing and cultivation on 3.7..2012
- Date of measurement: **4.7.2012**

Experimental design

	No.	150 m	150 m	150 m
untilled (winter barely stubble)	1.	Direktsaat (11 km/h) 3.4LS	Direktsaat (10 km/h) 3.3LS	Direktsaat (8 km/h) 2.4LS
untilled (winter barely stubble)	2.	Direktsaat (8 km/h) 2.4LS	Direktsaat (10 km/h) 3.3LS	Direktsaat (11 km/h) 3.4LS
untilled (winter barely stubble)	3.	Direktsaat (11 km/h) 3.4LS	Direktsaat (10 km/h) 3.3LS	Direktsaat (8 km/h) 2.4LS
untilled (winter barely stubble)	1.	Mulchsaat (8 km/h)	Mulchsaat (10 km/h)	Mulchsaat (11 km/h)
untilled (winter barely stubble)	2.	Mulchsaat (11 km/h)	Mulchsaat (10 km/h)	Mulchsaat (8 km/h)
untilled (winter barely stubble)	3.	Mulchsaat (8 km/h)	Mulchsaat (10 km/h)	Mulchsaat (11 km/h)
untilled (winter barely stubble)	4.	Direktsaat (11 km/h)	Direktsaat (10 km/h)	Direktsaat (8 km/h)
cultivated(15 cm)	1.	mit "Vorwerkzeuge" (8 km/h)	mit "Vorwerkzeuge" (10 km/h)	mit "Vorwerkzeuge"(11 km/h)
cultivated(15 cm)	2.	mit "Vorwerkzeuge"(11 km/h)	mit "Vorwerkzeuge" (10 km/h)	mit "Vorwerkzeuge" (8 km/h)
cultivated(15 cm)	3.	mit "Vorwerkzeuge" (8 km/h)	mit "Vorwerkzeuge" (10 km/h)	mit "Vorwerkzeuge"(11 km/h)
cultivated(15 cm)	1.	ohne "Vorwerkzeuge"(11 km/h)	ohne "Vorwerkzeuge" (10 km/h)	ohne "Vorwerkzeuge" (8 km/h)
cultivated(15 cm)	2.	ohne "Vorwerkzeuge" (8 km/h)	ohne "Vorwerkzeuge" (10 km/h)	ohne "Vorwerkzeuge"(11 km/h)
cultivated(15 cm)	3.	ohne "Vorwerkzeuge"(11 km/h)	ohne "Vorwerkzeuge" (10 km/h)	ohne "Vorwerkzeuge" (8 km/h)
cultivated(15 cm)	4.	ohne "Vorwerkzeuge" (8 km/h)	ohne "Vorwerkzeuge" (10 km/h)	ohne "Vorwerkzeuge"(11 km/h)
ploughed (20 cm)	1.	ohne "Vorwerkzeuge"(11 km/h)	ohne "Vorwerkzeuge"(10 km/h)	ohne "Vorwerkzeuge"(8 km/h)
ploughed (20 cm)	2.	ohne "Vorwerkzeuge"(8 km/h)	ohne "Vorwerkzeuge"(10 km/h)	ohne "Vorwerkzeuge"(11 km/h)
ploughed (20 cm)	3.	ohne "Vorwerkzeuge"(11 km/h)	ohne "Vorwerkzeuge"(10 km/h)	ohne "Vorwerkzeuge"(8 km/h)
ploughed (20 cm)	1.	mit "Vorwerkzeuge"(8 km/h)	mit "Vorwerkzeuge"(10 km/h)	mit "Vorwerkzeuge"(11 km/h)
ploughed (20 cm)	2.	mit "Vorwerkzeuge"(11 km/h)	mit "Vorwerkzeuge"(10 km/h)	mit "Vorwerkzeuge"(8 km/h)
ploughed (20 cm)	3.	mit "Vorwerkzeuge"(8 km/h)	mit "Vorwerkzeuge"(10 km/h)	mit "Vorwerkzeuge"(11 km/h)
ploughed (20 cm)	4.	mit "Vorwerkzeuge"(11 km/h)	mit "Vorwerkzeuge"(10 km/h)	mit "Vorwerkzeuge"(8 km/h)

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Date of Seeding: 4th July 2012 (16h45-18h31)
Seeding of peas (*Pisum sativum*): 114 kg/ha

Results
Mean Process parameter

Wheel speed (km/h)	N	Subgroup for α = 0.05 1	2	3
8 km/h	1767	8.13		
10 km/h	1189		9.79	
11km/h	1051			10.98
Vehicle speed (km/h)				
8 km/h	1438	8.24		
10 km/h	987		9.89	
11km/h	898			11.08
Slip (%)				
10 km/h	987	1.13		
11 km/h	897	1.20		
8 km/h	1430		1.42	
Engine speed (1/min)				
8 km/h	1767	1662		
10 km/h	1188		1709	
11km/h	1051			1799
Fuel consumption (l/h)				
8 km/h	1767	16.88		
10 km/h	1188		18.72	
11km/h	1051			20.23
Theoretical field performance (ha/h)				
8 km/h	1767	2.44		
10 km/h	1188		2.94	
11km/h	1051			3.29
Fuel consumption (l/ha)				
11 km/h	1051	6.15		
10 km/h	1188		6.38	
8 km/h	1767			6.92

Subgrouping according Student-Newman-Keuls test after ANOVA

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Selected results
Mean Fuel consumption (l/h)

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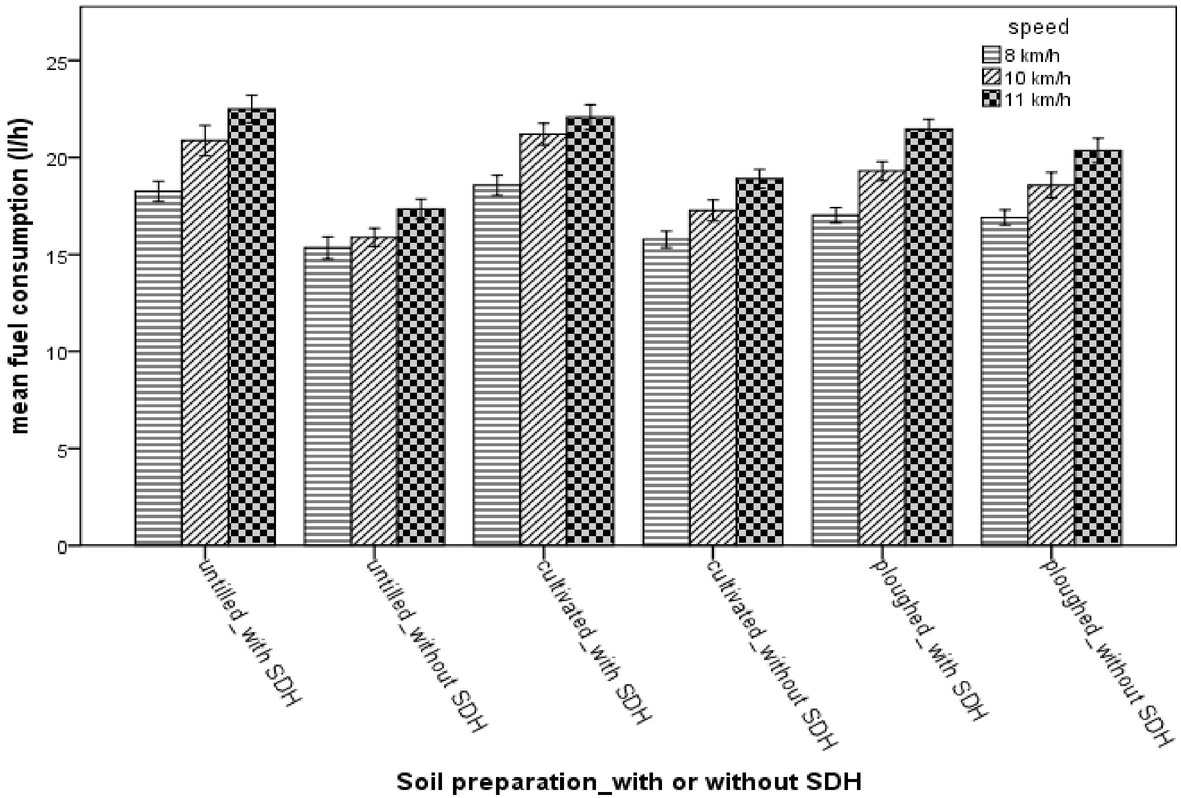

Process parameter

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Area fuel consumption B_A:

$$B_A \left(l\ ha^{-1}\right) = B \times T_A$$

B: hourly fuel consumption (l/h)

T_A: technical field operation time (h/ha)

$$T_A \left(h\ ha^{-1}\right) = \frac{1}{C_A}$$

C_A: Theoretical field performance (ha/h):

$$C_A \left(ha\ h^{-1}\right) = b \times v \times 0.1$$

v: vehicle speed (km/h)
b: technical working width (cm)

Mean Fuel consumption (l/ha)

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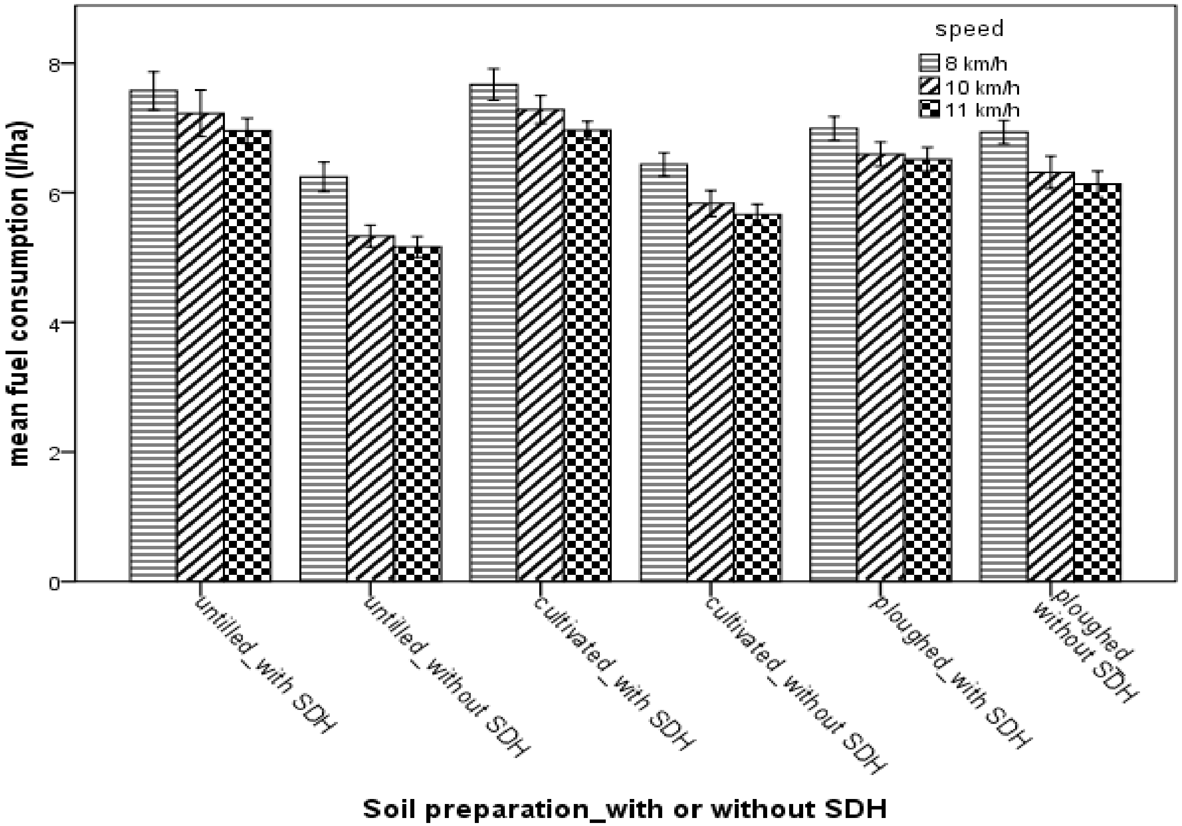

Pea plants in a square meter after 55 days of seeding

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Plants per m²	N	Subgroup for α = 0.05[1]		
		1	2	3
Untilled_without SDH[2]	62	9.2		
Untilled_with SDH	53	10.4		
Cultivated_with SDH	52	10.8		
Cultivated_without SDH	72	11.2		
Ploughed with SDH	72		14.0	
Ploughed without SDH	54			16.0

[1] Student-Newman-Keuls procedure with the statistic programme SPSS 18.
[2] Short Disc Harrow in the unverisal seed drill

Climate parameter for 55 days:
=> Average air temperature: 21.2° C
=> Precipitation : 106 mm.


Untilled_without SDH („Direct seeding“)


Culivated with SDH („Mulch seeding“)


Ploughed with SDH („Mulch seeding“)

Conclusions and Outlook

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- The carried out experiment realized the highest speed (v=11.0 km/h), which was at the performance limit of the used tractor engine (P_e= 92 kW). Experiences from the farmers show, that seeding with an universal pneumatic seed drill are usually in the speed range between v=13.0 - 15.0 km/h because they use a more powerful tractor.
- With increased speed the hourly fuel consumption (l/h) increased while the area fuel consumption (l/ha) decreases because of the increase of the theoretical field performance. The effect of seeding speed on the soil disturbance caused by the interaction between soil/disc coulter or soil/tines should be investigated, because there rare data for tillage erosion by seeding.
- Future research should be focused on embedding of different kind of seeds with the vertical and horizontal distribution under firm soil conditions. Also the comparison of the whole cropping system with the different seeding strategies of the universal pneumatic seed drill at different site conditions (climate and soil) is necessary.

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ACKNOWLEDGEMENT

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Tillage and tillage systems - Definitions

„Tillage" is the mechanical manipulation of soil

„Tillage System" is the sequence of operations that manipulates the soil to produce a crop:

- Tilling
- Planting
- Harvesting
- Chopping or shredding residue

Stratified Seedbed

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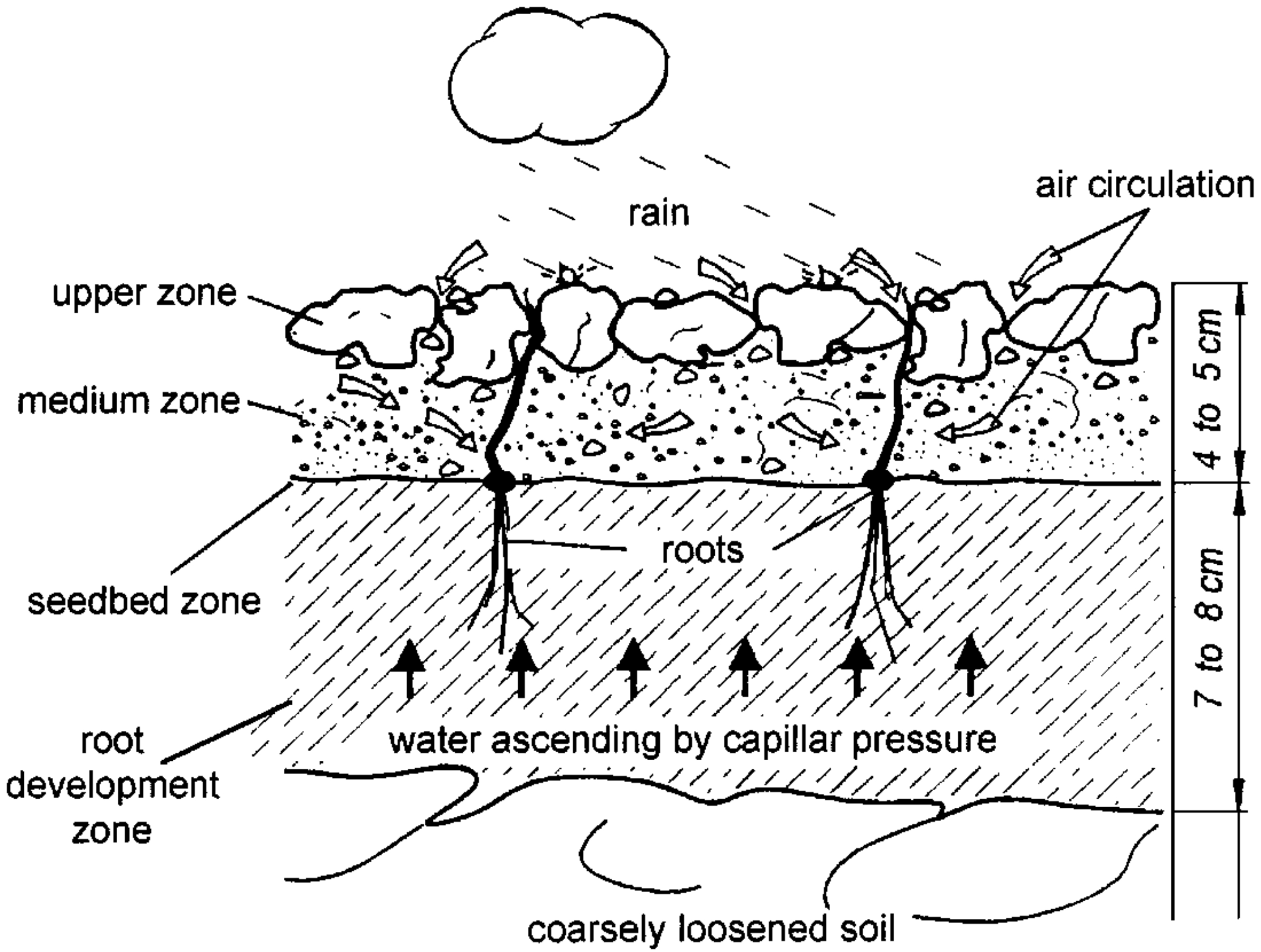
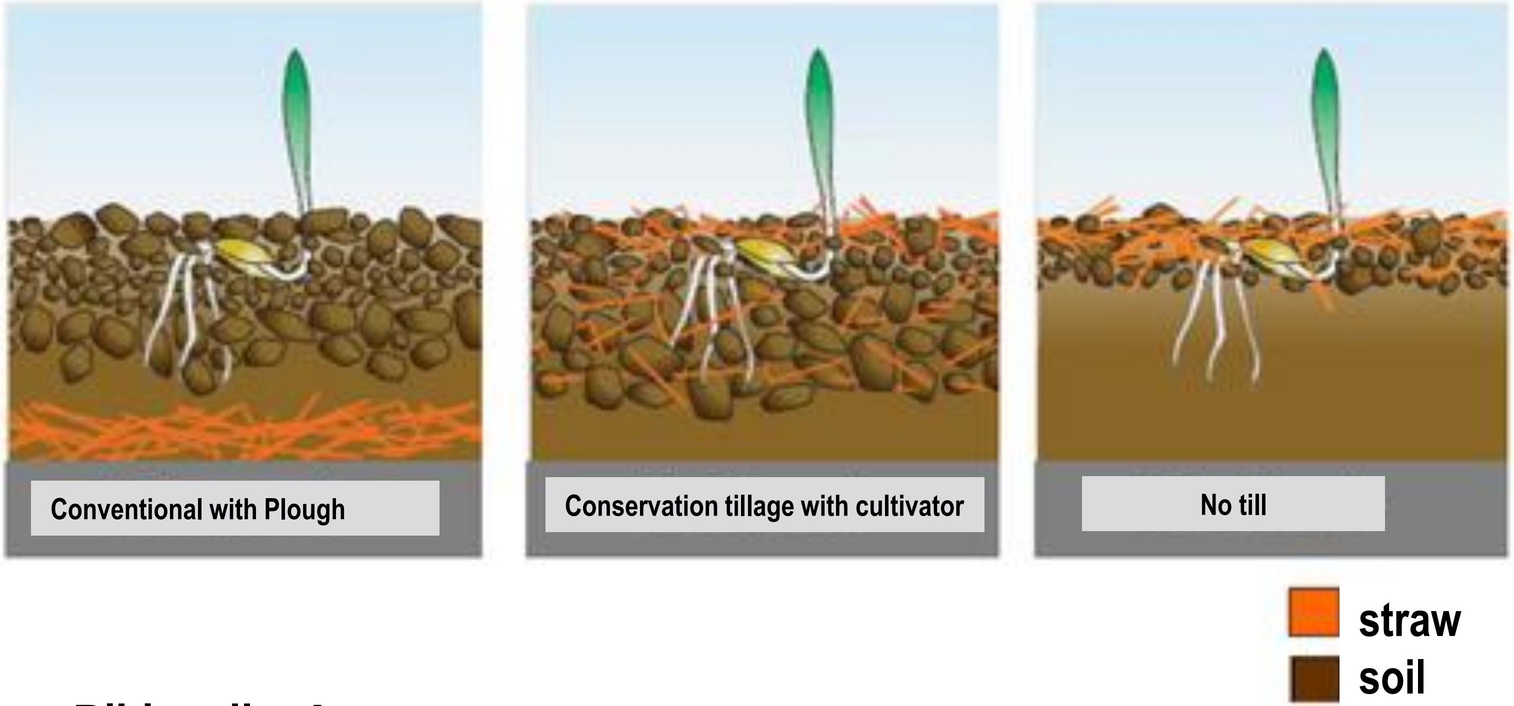


Source: CIGR Handbook of Agricultural Engineering, Volume III Plant Production Engineering..American Society of Agricultural Engineers, (ASAE), 1999

Placement of straw

Bildquelle: Löser

Bildquelle: Brunner



Bildquelle: Amazone

Infection ways of Fusarien (Weinert, 1995)

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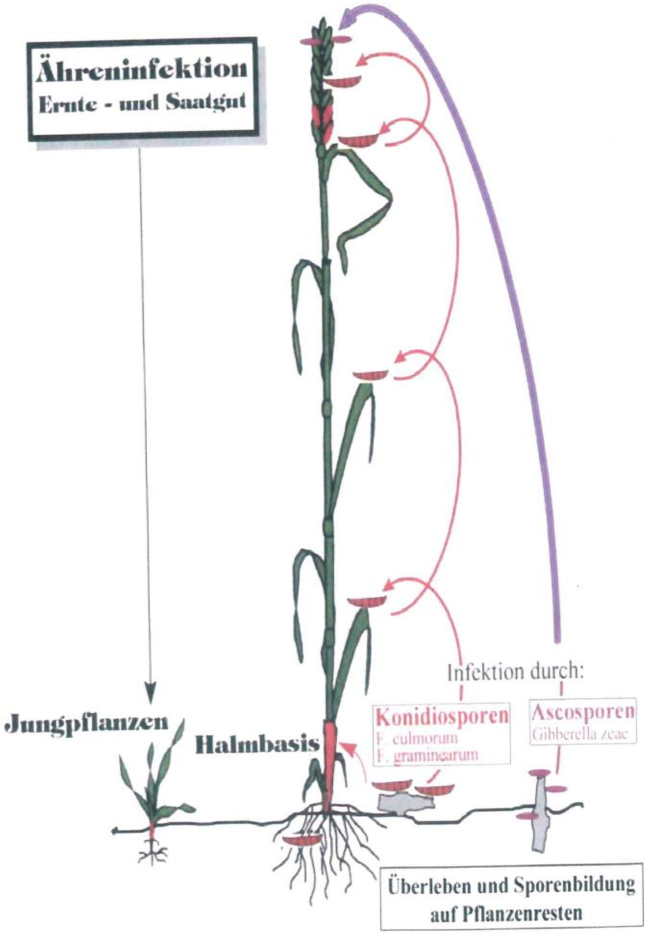

Influence factors to Fusarium-mycotoxin formation in cereals:

- **Previous crop** to wheat (maize, cereals)
- **Tillage** to wheat (with plough, without plough)
- **Variety** of wheat and maize (susceptible, non susceptible)
- **Crop management** (N-ferilization, growth regulators)
- **Weather conditions** at blooming of wheat (humid, dry)

Quelle: Brunotte, J.: Konservierende Bodenbearbeitung als Beitrag zur Minderung von Bodenschadverdichtungen, Bodenerosion, Run off und Mykotoxinbildung im Getreide. FAL-Sonderheft 305, 2007

Mycotoxine (DON) - formation in winter-wheat in dependance of previous crops and tillage

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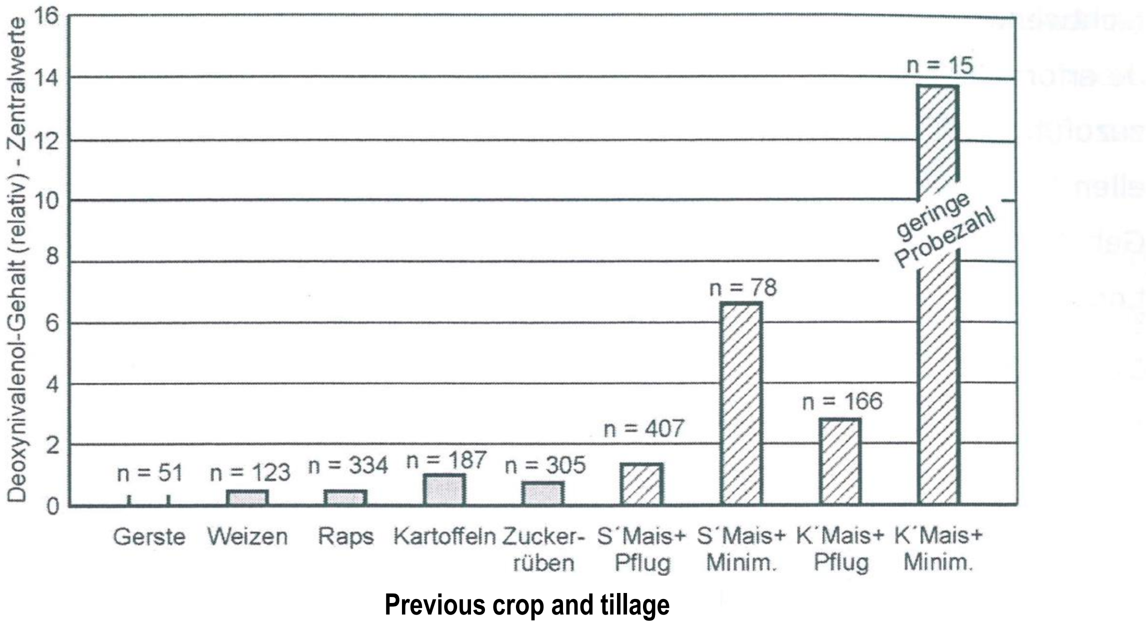
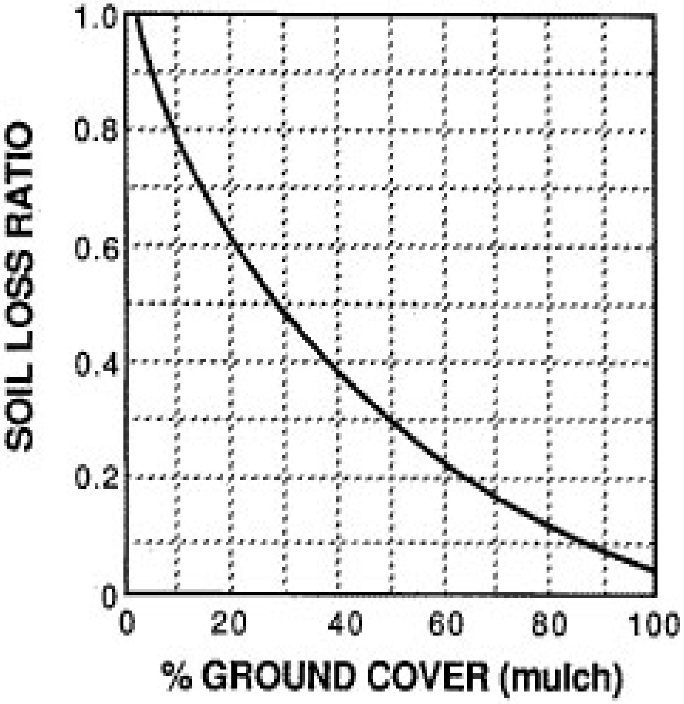


Abb. 3: DON-Gehalt von Winterweizen (Ernte 1993-1999) in Abhängigkeit von Vorfrucht und Bodenbearbeitung (nach Beck & Lepschy, 2000)

Gerste: barely
Weizen: wheat
Raps: rape-seed
Kartoffeln: potatoe
Zuckerrübe: sugar beet
Mais: maize, corn
Pflug: plough
Minim. Conservation tillage

Quelle: Brunotte, J.: Konservierende Bodenbearbeitung als Beitrag zur Minderung von Bodenschadverdichtungen, Bodenerosion, Run off und Mykotoxinbildung im Getreide. FAL-Sonderheft 305, 2007

DON: deoxynivalenol (major toxin produced by *Fusarium graminearum)*



Experimental Farm