FiBL
EXCELLENCE FOR SUSTAINABILITY

Research Institute of Organic Agriculture
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Institut de recherche de l'agriculture biologique






Genotype x management interaction for nutrient use efficiency (NUE) of maize varieties tested under different tillage and fertilization regimes

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Der Coop Fonds für Nachhaltigkeit unterstützt dieses Projekt.
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NUE-Crops

Background:

- **Promotion of Reduced Tillage (RT) in Organic Farming to combine benefit of both systems**
  - Higher organic matter (CO_2 sequestration)
  - Reduced risk of nitrate leaching and erosion
  - Improved soil structure and water holding capacity
  - Increased earth worm populations and microbial activity
  - **Persistent weeds**
  - **Delayed mineralisation of organic fertilizer in cold spring**
- **Nutrient use efficient (NUE) Genotypes needed that can cope with slow releasing fertilizer that might not mach nutrient demand at all times**

Objectives: Test for Genotype x Management Interaction

- To quantify the **expression of Nit-UE** of maize varieties under different tillage and fertilisation regimes
- To compare the effects of **slow releasing organic** versus mineral fertilizer at different input levels
- To determine **cultivar x fertiliser x tillage interactions**

➡ **Integrating of Breeding & Managment**

Experimental Design

- **Sites**
  - **Muri (Canton Aargau): sandy loam**
  - **Aesch (Canton Basellland): silty loam (loess)**

  Both under organic management since more than 6 years

- **Same Crop Rotation with 1 year difference**
  - **gras clover - maize – winter faba – winter wheat**

- **Factors:**
  - **Cultivars:** **6 maize cultivars differing in Nit-UE**
  - **Tillage:** **Reduced tillage *vs.* Conventional Tillage**
  - **Fertilisation:** **Slurry *vs.* mineral fertilizers, two levels and unfertilized control**

Sites:	Sentenhof Muri AG	Schlatthof Aesch BL
Soil typ:	Sandy loam	Silty loam
Av. Temperature:	8.8 ° C	11.7 ° C
Av. Precipitation:	1200 mm	790 mm
Altitude:	460 m a. S L	350 m a. S L
Humus content:	3.0%	2.8%
P_{avail} [kg/ha] 0-20 cm	11	16
K_{avail} [kg/ha] 0-20 cm	50	117
N_{min} [kg/ha] 0-60 cm	28 (CT); 33 (RT)	93 (CT); 64 (RT)
Maize sowing time:	12.05.2009	25.05.2010
Harvesting time:	18.09.2009	30.09.2010

Tillage (2 levels)

Conventional tillage (CT):

with mouldboard plough
Converting soil **up to 18-20 cm deep**

Reduced tillage (RT):

(=minimum tillage)

with **Stubble cleaner** = skin plough
Converting **only top soil 5-7 cm deep**

Fertilization to maize (5 levels) in Muri and Aesch

Fertilizer Input	N total* [kg/ha]	N available [kg/ha]	P_2O_5 [kg/ha]	K_2O [kg/ha]
Control (unfertilized)	0 0	0 0	0 0	0 0
Organic low (Slurry1)	82 68*	48 (58%) 28* (41%)	31 36	49 108
Organic high (Slurry2)	155 135*	90 (58%) 54* (41%)	60 70	96 214
Mineral low (NPK1)	85 63*	85 63*	40 40	110 110
Mineral high (NPK2)	170 127*	170 127*	80 80	220 220

* Fertilization was reduced in Aesch by 21 and 42 kg N/ha, respectively, due to difference in N_{min} in soil at sowing time (78 kg/ha in Aesch vs. 31 kg/ha in Muri) to comply with maximum limit of 200 kg N/ha

Maize varieties used:

	Hybrids	Breeder	Maturity	FAO	Characteristics
S1	**Ricardinio**	KWS (DE)	Medium-early	S230 K220	standard var. high yielding
S2	**Coxximo**	R.A.G.T. (FR)	Early maturing	S230 K230	standard var.
S3	**Fernandez**	KWS	Medium-early	S250	QTL conferring **low Nit-UE**
S4	**Torres**	KWS	Medium-early	S250 K260	QTL conferring **high Nit-NUE**
S5	**Apekt= Anjou 227**	Saaten Union (DE)	Early maturing	S210 K220	standard var.
S6	**Grosso**	KWS	Medium-early	S250	QTL for high Nit-NUE

Experimental design: Split Split Plot design

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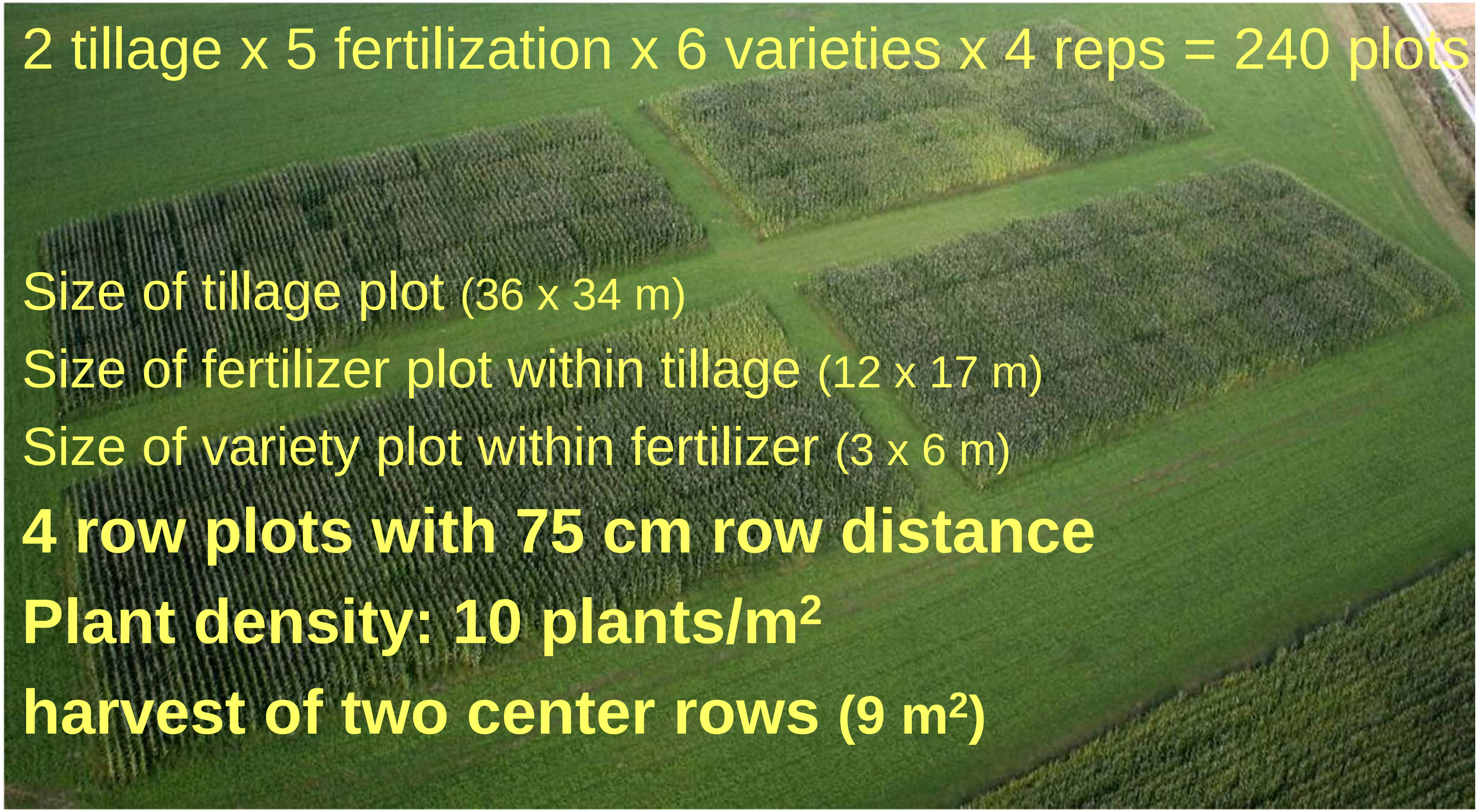


Schlatthof, Aesch (BL)

Analysis and records in 2009 and 2010

- Number of plants
- Plant height
- Anthesis and silking date
- Pests (European corn borer, 2009) and Disease (smut in 2010)
- Weeds 3x
- Chlorophyll content (SPAD 2x)
- Yield of silage maize (DMY, DM content)
- Product quality (crude protein, energy content)
- N, P, K in plants at harvest
- N, P, K in fertilizers
- Soil parameters (humus content, pH, soil nutrients)
- Detailed records for socioeconomic analysis

Significant Effects and Interactions of Silage Maize experiment across environmental sites Muri and Aesch

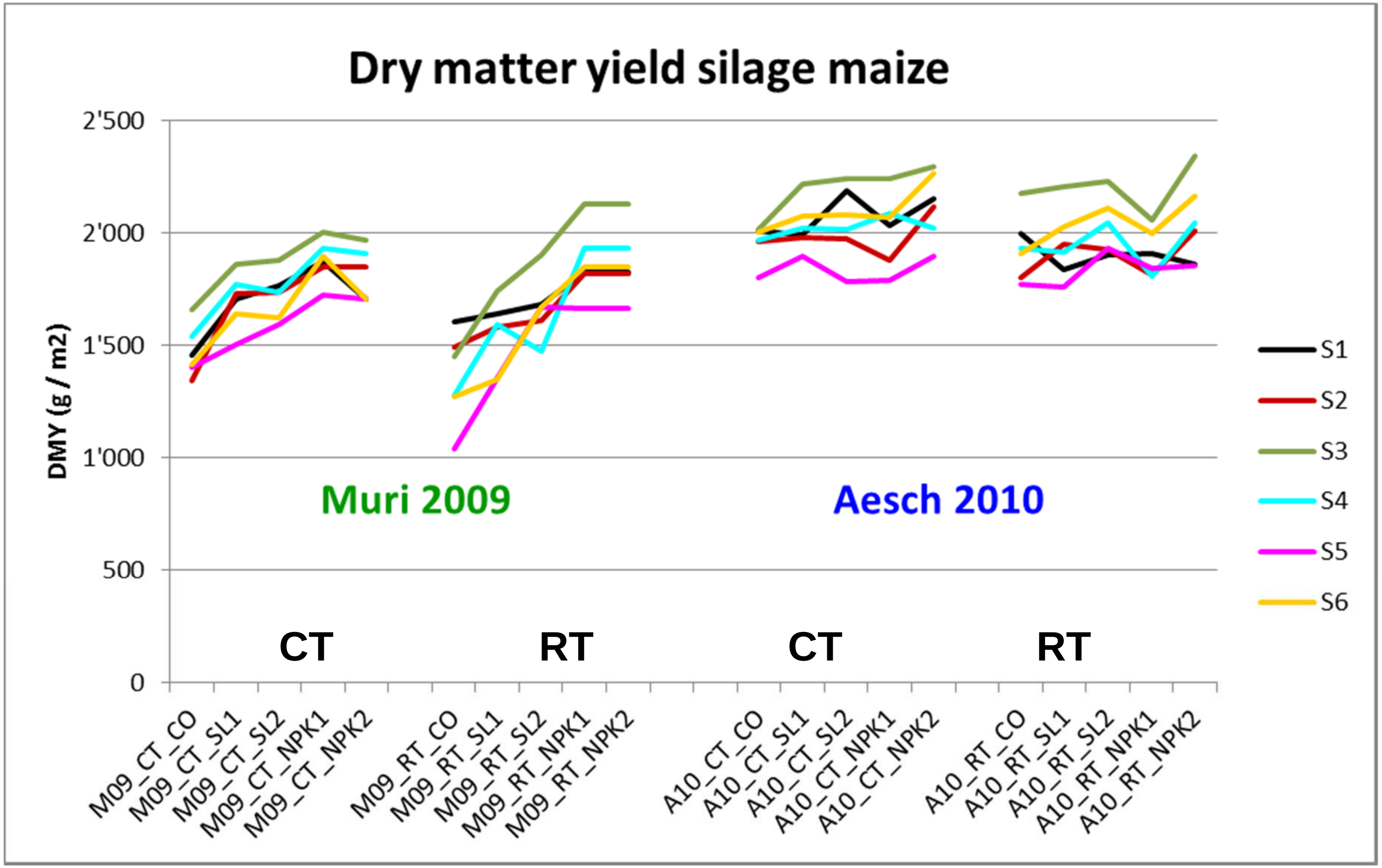
Trait	Till.	Fert.	Var.	T x F	V x T	V x F	V x F x T	V x F x T x E
Plant height		***	***			***		*
Anthesis Silking Int.	+		***		***			
Weeds	***		***			*	+	
SPAD	*	***	***	***				
Dry matter yield	+	***	***					
Energy (NEL) MJ/kg			***				*	
N concentation	**	***	***					
P concentration	*	*	***			+		
N Use Efficiency		***	***			***	**	***
P Use Efficiency		***	***			***	**	***

+ P<0.1; * P<0.05; ** P<0.01; *** P<0.001

Rank correlations between traits

Trait 1	Trait 2	Muri 2009	Aesch 2010
DM yield	Weed pressure	**- 0.27**	n.s.
DM yield	Days to silking	n.s.	**+ 0.52**
DM yield	DM content	n.s.	n.s.
DM yield	Plant height	**+ 0.62**	**+ 0.37**
DM yield	Net energy lactation	n.s.	n.s.
DM yield	Chlorophyll content	**+ 0.52**	**- 0.42**
DM yield	N concentration	**+ 0.34**	n.s.
DM yield	P concentration	**- 0.37**	n.s.
N concentration	Chlorophyll content	**+ 0.59**	**+ 0.58**

Response of Varieties to Tillage and Fertilization



Significant effects: Env, Fert, Var, VxE

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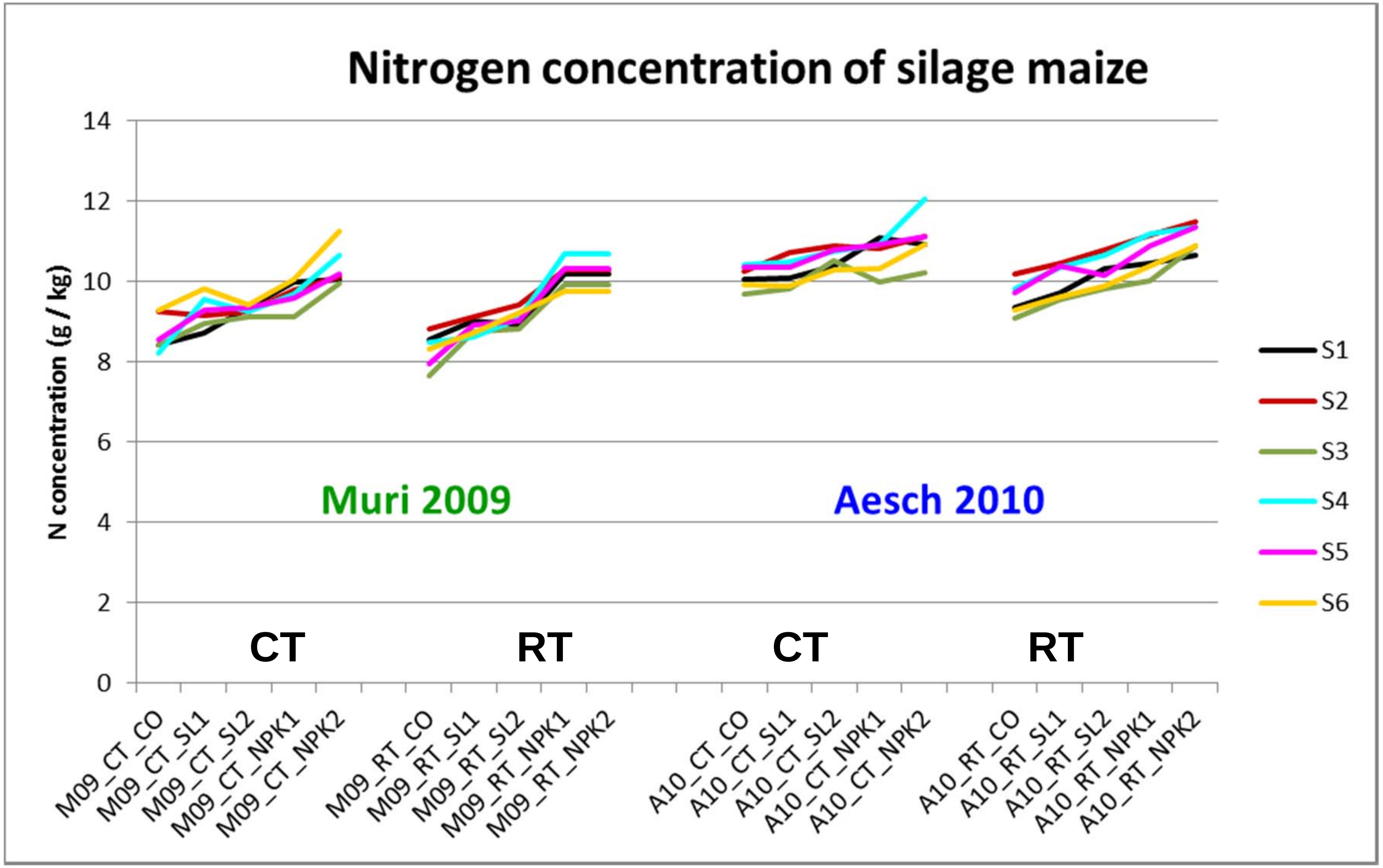
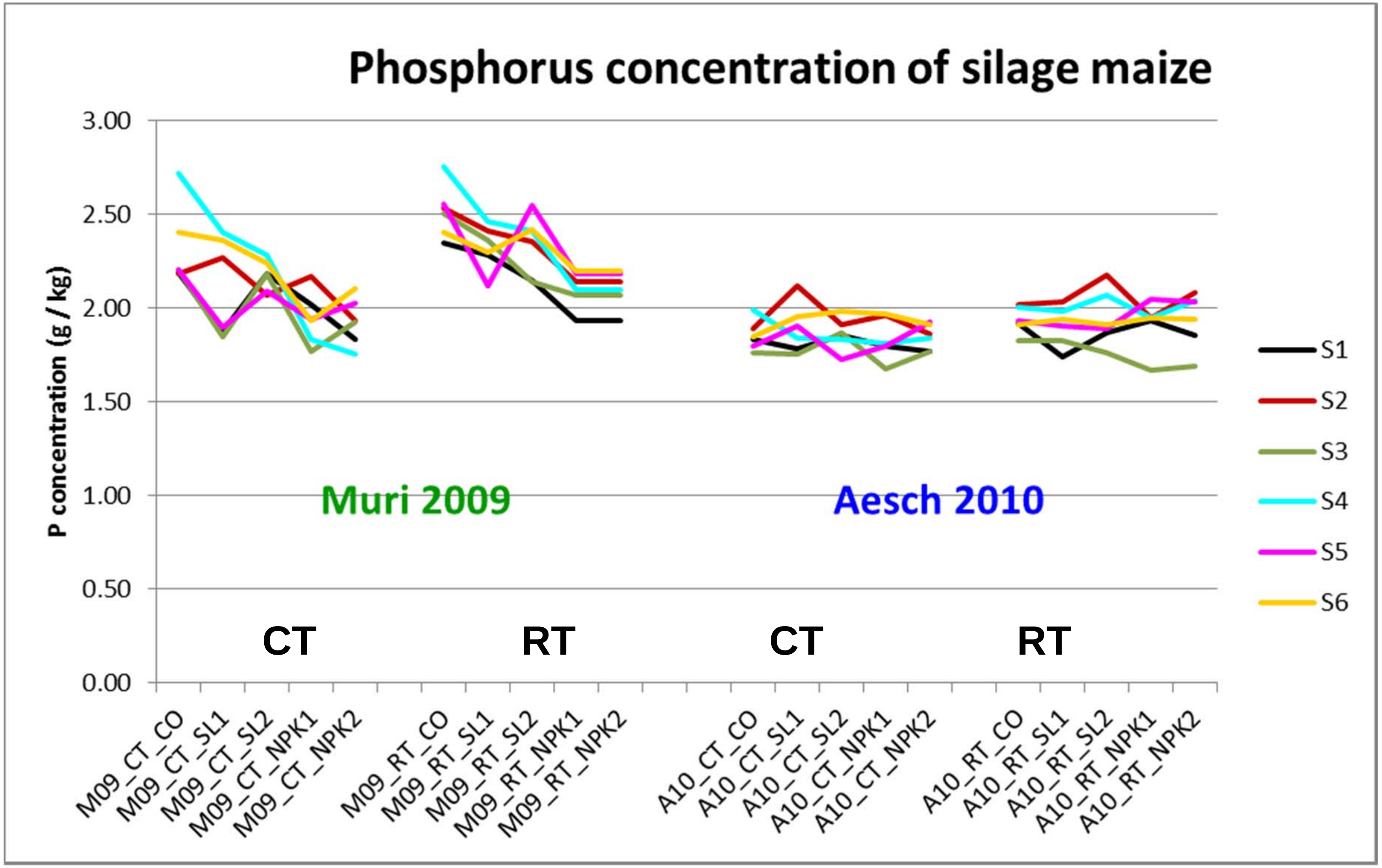


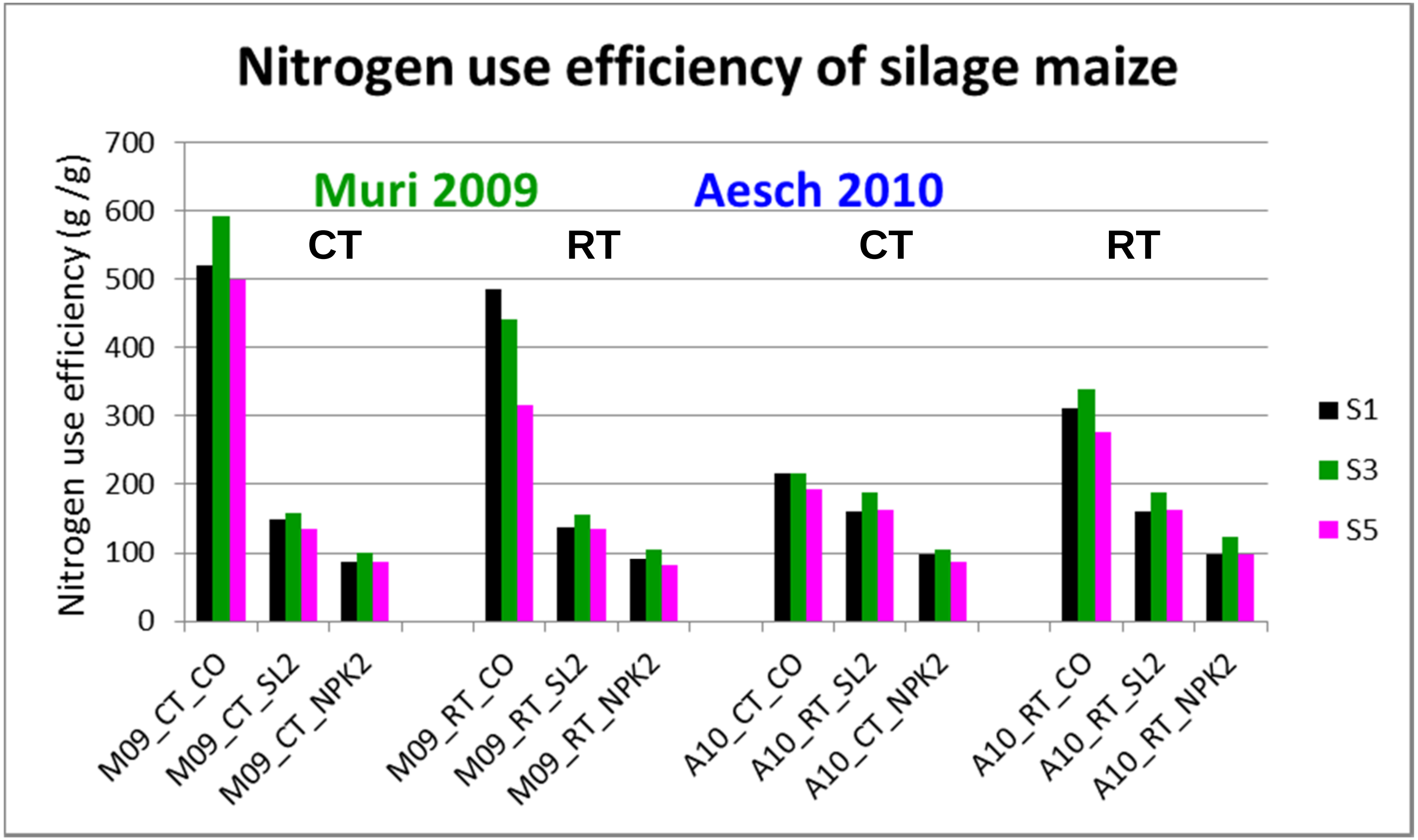
Significant effects: Env, Till, Fert, Var, VxE

Response of Varieties to Tillage and Fertilization



Significant effects: Env, Til, Fert, Var, VxF

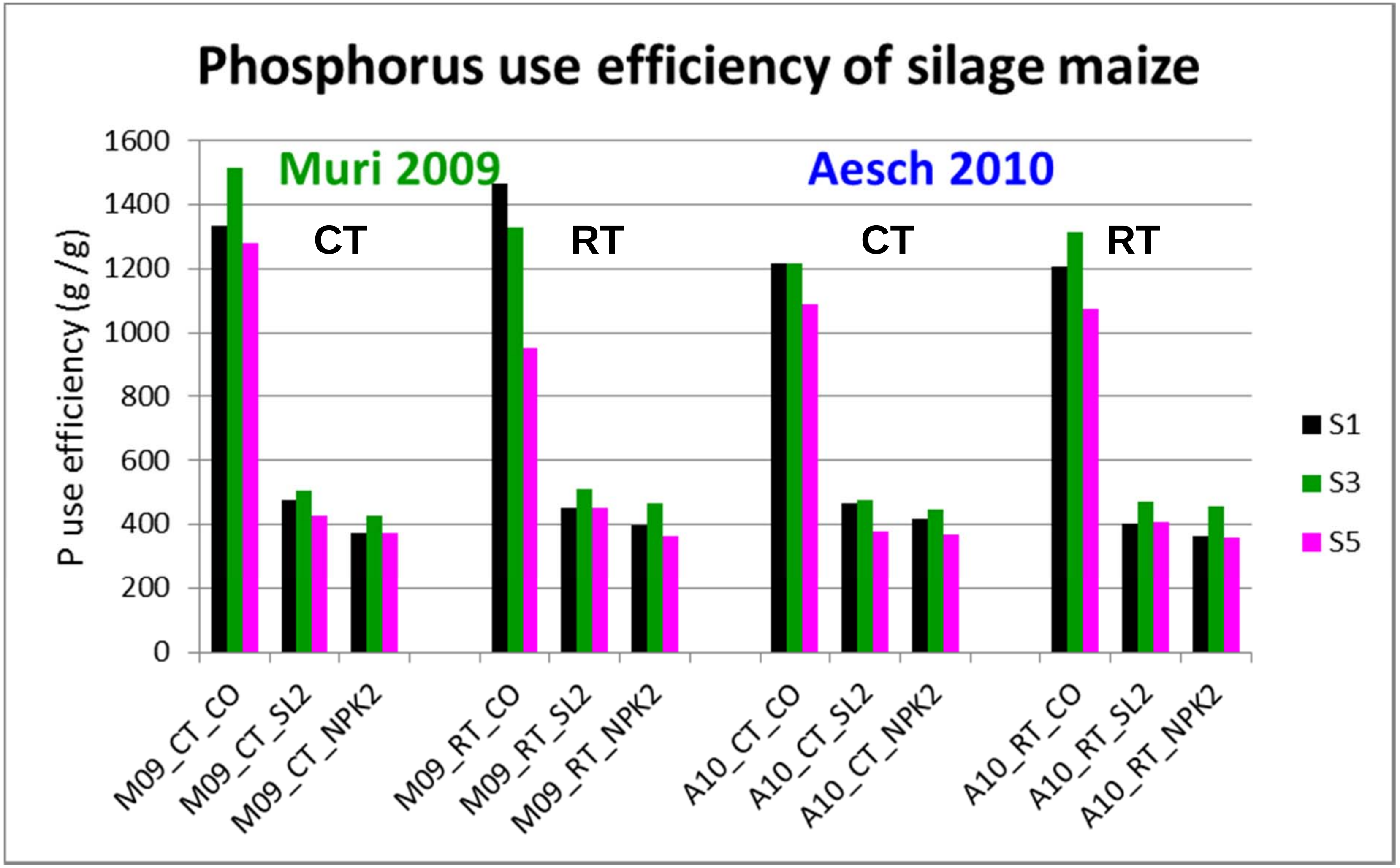
Response of Varieties to Tillage and Fertilization



Significant effects: Env, Fert, Var, VxF, VxE, VxFxT, VxFxTxE

Nitrogen Use Efficiency = Yield / (N input fertilizer + Nmin soil)

Response of Varieties to Tillage and Fertilization



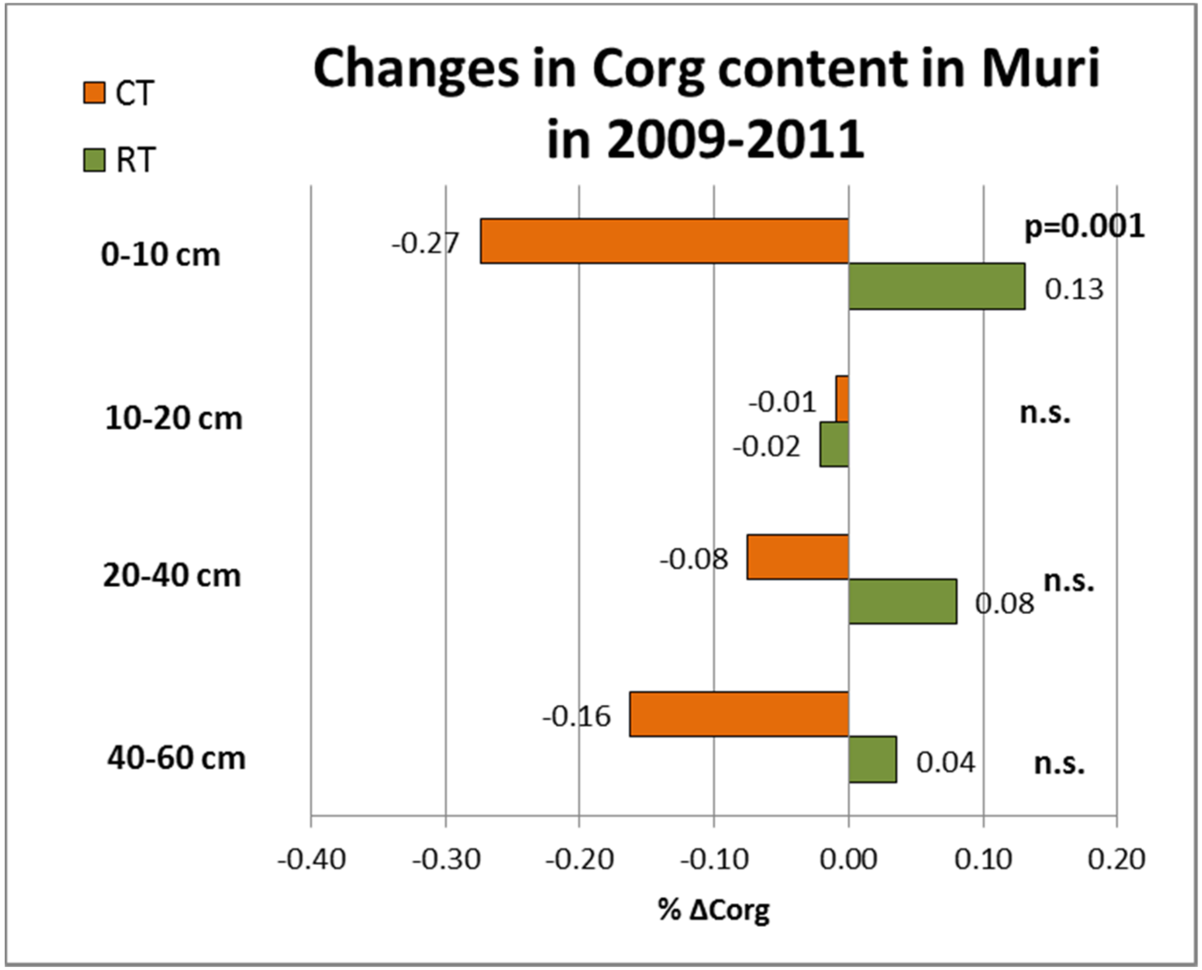
Significant effects: Fert, Var, VxF, VxE, VxFxT, VxFxTxE

Phosphorus Use Efficiency = P uptake / (P input fertilizer + Pavail soil)

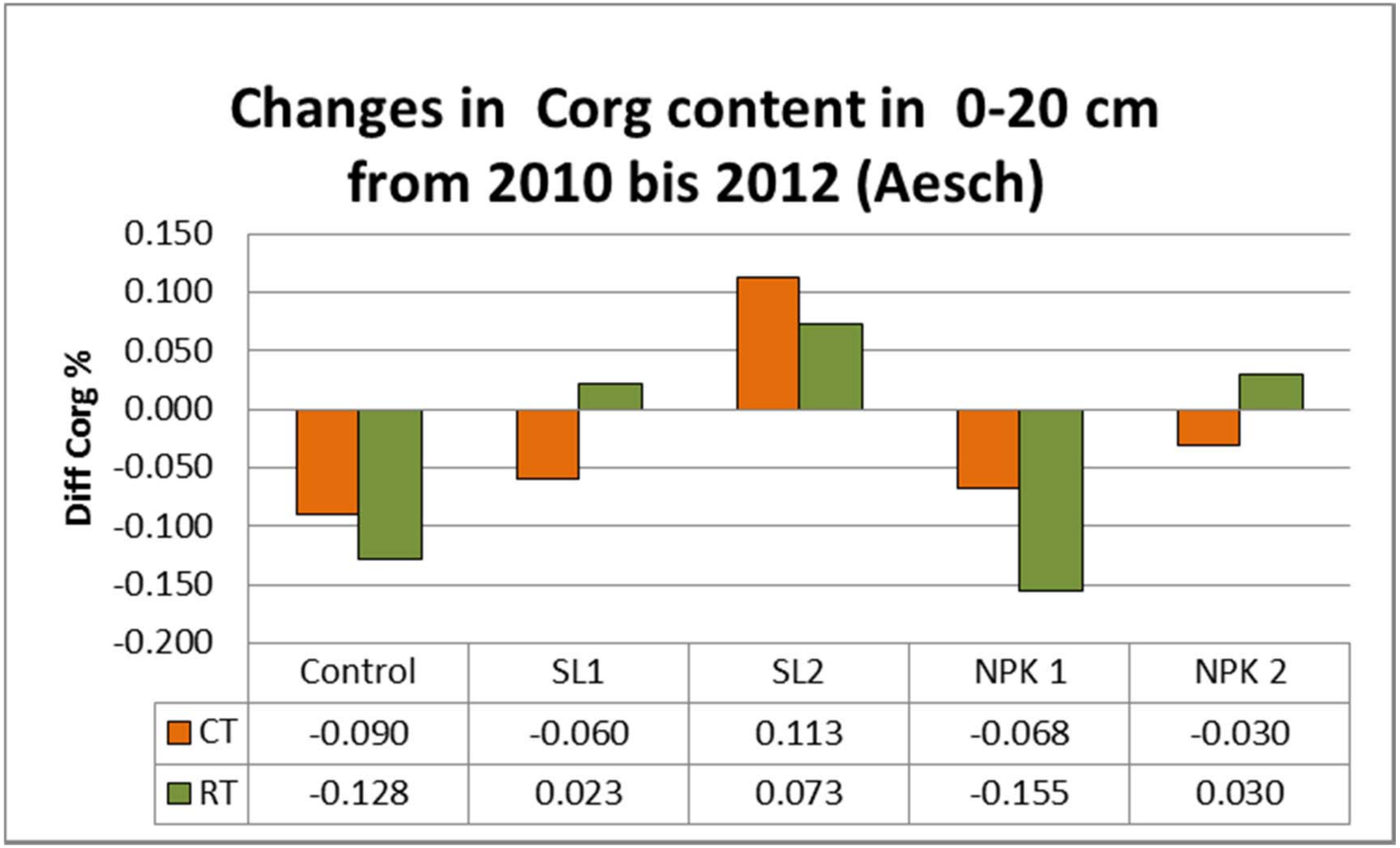
Nutrient balance of the two sites

Env.	Till.	Fert.	N input soil + fert. (kg/ha)	P input soil + fert (kg/ha)	K input soil + fert. (kg/ha)	N uptake (kg/ha)	P uptake (kg/ha	K uptake (kg/ha)	N mobil. (kg/ha)	P mobil (kg/ha)	K mobil. (kg/ha)
Muri 2009	**CT**	**CO**	**28.0**	**11.0**	**49.8**	**127.2**	**34.2**	**120.0**	**99.2**	**23.2**	**70.2**
Muri 2009	CT	SL2	118.0	37.2	128.7	160.0	37.3	146.0			
Muri 2009	CT	NPK2	198.0	45.9	232.4	187.0	35.1	163.2			
Muri 2009	**RT**	**CO**	**33.0**	**11.0**	**49.8**	**110.7**	**32.8**	**104.8**	**77.7**	**21.8**	**55.0**
Muri 2009	RT	SL2	123.0	37.2	128.7	151.7	38.3	135.9			
Muri 2009	RT	NPK2	203.0	45.9	232.4	191.1	39.5	160.5			
Aesch 2010	**CT**	**CO**	**93.0**	**16.5**	**117.2**	**198.1**	**36.4**	**163.7**	**105.1**	**19.8**	**46.5**
Aesch 2010	CT	SL2	147.3	47.2	294.9	215.0	38.2	192.3			
Aesch 2010	CT	NPK2	220.5	51.4	299.8	234.3	39.2	195.9			
Aesch 2010	**RT**	**CO**	**64.0**	**16.5**	**117.2**	**185.1**	**37.5**	**150.8**	**121.1**	**20.9**	**33.7**
Aesch 2010	RT	SL2	118.3	47.2	294.9	207.6	39.2	173.6			
Aesch 2010	RT	NPK2	191.5	51.4	299.8	227.8	39.8	171.7			

Changes is soil organic matter in relation to tillage



Changes in soil organic matter in relation to different tillage and fertilization



	Control	SL1	SL2	NPK 1	NPK 2
CT	-0.090	-0.060	0.113	-0.068	-0.030
RT	-0.128	0.023	0.073	-0.155	0.030

Summary:

- **Reduced tillage resulted in** higher weed pressure, reduced chlorophyll and N content, but similar dry matter yield, net energy and nutrient use efficiency
- Yield increased significantly from the **unfertilized controll to slurry and to mineral fertilizer**, however, doubling the amount of either slurry or NPK had no significant effect on yield, but increased soil organic matter
- **Genotypes** differed significantly for all important traits and significant **genotype x management interaction** were found for plant height, silking time, weed density, net energy lactation and nutrient uptae efficiency and nutrient use efficiency

Acknowledgements:

- the organic farmers Ueli Ineichen and Rène Leimgruber for providing the field and conducing the field management
- Röbi Frei, Maike Krauss, Robert Kunz for supporting the assessment in the field and lab

Financial support of

FP7 NUE-CROPS

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Coop sustainability fund

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THANKS FOR YOUR ATTENTION!