Environmental Impact Analysis of Alternative Management Practices in Baden Württemberg

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INSEA

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Outline:

- Data and Methodology
- Input Validation for SOC
- Preliminary EPIC Results
  - Crop Yield, SOC, Sediment Yield
- Alternative Management Practices
- Environmental Impacts of Alternative Management Practices
- Summary

INSEA:
Data for modelling EU25

GROUP	DATA SET	DESCRIPTION
climate	MARS	Monitoring of Agriculture with Remote Sensing (50 km)
	EAST ANGLIA	Tyndall Centre for Climate Change Research (0.5˚)
	EMEP	Monitoring and evaluation of the long-range transmission of air-pollution in Europe (50 km)
Soil	ESDB v.2	The European soil database v. 2. (10 km, 1 km)
	OC TOP v. 1.2	The map of Organic Carbon in the Topsoils in Europe, Ver. 1.2
	HYPRESE	Hydraulic Properties of European Soils (PTF Data)
Topography	GTOPO30	Global digital elevation model (30 arc seconds)
Land Cover	CORINE/PELCOM	Combined CORINE and PELCOM (1 km)
Admin. region	AGISCO	Geographic Information System of European Commission data
Reference grid	SWU	JRS Soil and Waste Unit reference grid (10 k)
Agricultural statistics	NEW CRONOS	New Cronos Regional Statistics (NUTS2, NUTS1)
	LUCAS	Land use and land cover area frame statistical survey project data (Phase I.)
	MARS	Monitoring of Agriculture with Remote Sensing (50 km)

HRU delineation

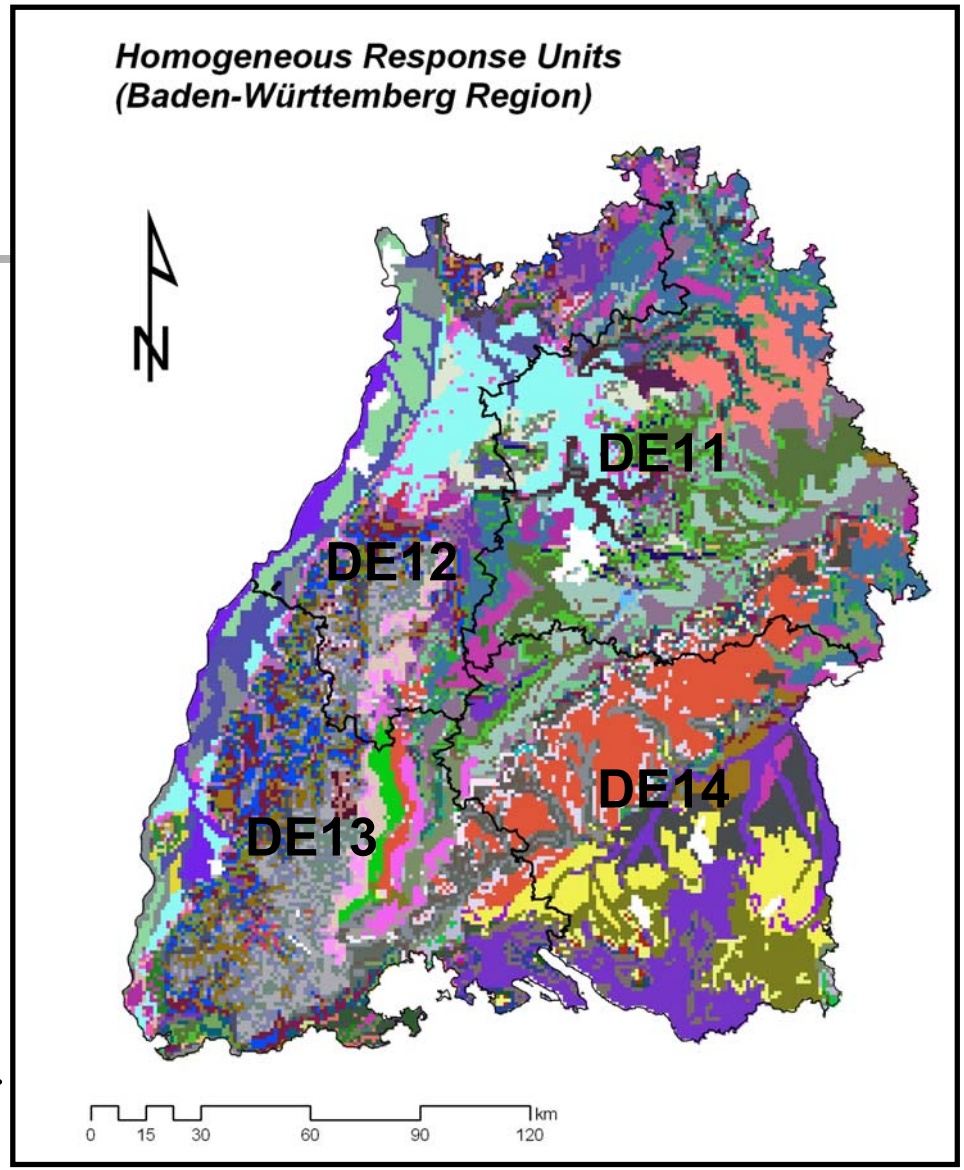
Altitude:
1. < 300 m
2. 300-600 m
3. 600-1100 m
4. >1100 m

Texture:
1. Coarse
2. Medium
3. Medium-fine
4. Fine
5. Very fine

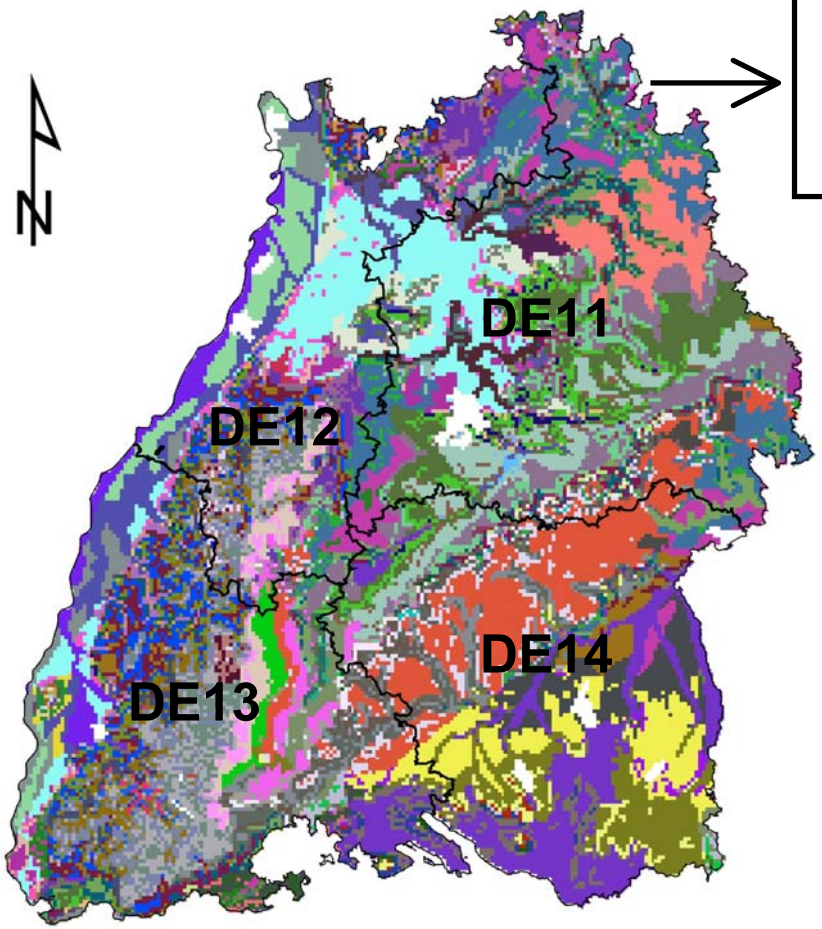
Stoniness:
1. Low content
2. Medium content
3. High content

Slope Class:
1. 0-3%
2. 3-6%
3. 6-10%
4. 10-15%
5. …

Soil Depth:
1. shallow
2. medium
3. deep



Homogeneous Response Units (Baden-Württemberg Region)



GIS Zone Processing specific for Land Categories

CORINE-PELCOM

INSEA 1 km Soil & Topo Database

105_OUT - WordPad

Súbor Úpravy Zobraziť Vložiť Formát Pomocník

NUTS2	LandCat	temp	km2	cec_top	cec_sub	bs_top	bs_sub	sand_top	sand_sub	silt_top	silt_sub	oc_top	vs_top
105	312	0	21	24.86631457010905	9.661214238121396	42.93419456481934	36.76309494745163	39.93607148670015					
105	312	0	3	21.57849947611491	15.42949994405111	73.4499994913737	56.93333180745443	26.86166699727376	1				
105	312	0	354	24.62140514891026	11.31026100438867	45.33192396972139	38.55983108046365	36.23361599916795					
105	312	0	22	23.966172738508750	24.5085861899636	78.97833251953125	71.27336398037997	15.08661356839267					
105	312	0	115	20.96301834272302	9.029394688813582	48.69383989417035	40.52227388464886	43.16229669322135					
105	312	0	1786	25.54402063781977	11.17894458984341	44.31918063809864	38.16978007441539	32.20161754633778					
105	312	0	83	22.71097943868982	25.819338810013	84.05876573309841	74.43982145010708	13.16818503873894	1				
105	313	0	7	19.78080054691860	13.91545745304653	69.02839878627232	59.47143009730748	30.46500042506627	2				
105	313	0	102	22.43239047480564	10.52935690973319	50.01291596655752	41.38431410695992	36.96816191953770					
105	313	0	61	15.54066381298128	11.94646238108150	80.55990938280449	67.47663854380123	39.91441307693231					
105	313	0	755	20.70015850698711	9.98165099668187	54.49165473079050	44.98629889077698	38.39876127053573					
105	313	0	1	25.96439933776856	28.33849906921387	84.06719970703125	74.625	8.637499809265137	7	53.966098			
105	313	0	21	14.45357145581927	9.587857428051176	83.58714294433594	70.24761781238374	51.55214327857608					
105	313	0	663	25.02725432469295	12.53180623234307	50.64543699319187	43.50459207272997	30.77296214729411					
105	313	0	20	24.30283508300781	27.57282991409302	84.75117034912110	74.79000015258789	9.967697143554688					
105	311	0	13	16.64523858290452	10.54925383054293	60.26624532846304	62.10769301194411	49.77692354642428					
105	311	0	286	18.42013584817206	13.14959880188629	71.35314347860697	69.27596177587977	35.26678958972850					
105	311	0	29	17.00529621387350	11.75711717276738	76.57073132745151	64.13103327257880	37.29689644122946	1				
105	311	0	163	17.86240367070298	13.85562658602475	70.40839650440802	58.59677929088382	31.47529188401860					
105	311	0	6	16.10549990336100	10.01500034332275	83.66666666666667	70.39999898274739	45.25333340962728	10				
105	311	0	50	24.36894008636475	16.21078990936279	63.79810218811035	56.72899993896485	24.84033849716187					
105	21	0	82	17.38460024391733	12.53779148473972	67.42686522879252	64.83109804479088	42.71326244168165					
105	21	0	467	17.43095261330778	13.74218324624497	71.79853550422881	68.56638131968725	34.78227566753771					
105	21	0	63	14.16927128746396	11.39331272670201	81.78420584542411	69.26190415639726	39.74952364724781					
105	21	0	398	15.23153463440325	13.31401673513441	78.73232267370176	67.99197338813514	34.99005161218308					
105	21	0	31	25.24936768316454	27.19336731203141	79.35297836795930	72.72983870967742	16.66988040554908	1				
105	21	0	25	15.80155986785889	9.756039962768554	84.32746459960937	70.03999938964844	45.25466690063477					
105	21	0	250	21.54343679428101	20.46482600402832	81.41040472412109	72.15700997924805	18.49241475296021					
105	21	0	82	22.65603153880049	25.36481226944342	83.76252746582031	73.88614403329244	14.29754345591475					
105	22	0	3	18.72179985046387	15.77396678924561	80.40166473388672	72.56666819254558	30.22166697184245	2				
105	22	0	143	18.17059877702406	15.04371919832030	70.05485993498689	63.76573445246770	30.88676942145074	2				
			1	19.97299957275391	16.98950004577637	83.34999847412109	62.59999847412109	24.67000007629395	8				
			62	18.14974052675309	14.95081195523662	67.29693523530037	60.95322578184067	30.52891642047513					
			2	17.68175029754639	8.039000034332275	57.77499961853027	50.25	44.08749961853027	31.25	31.1625			
			2	16.53125047683716	10.91524982452393	62.23999786376953	61	51.20375061035156	49.48125076293945				
			102	19.65157375148699	10.95424907347735	62.32640333736644	59.49142119463753	37.88403540966558					
			13	18.52024606557993	13.23175386282114	75.75637641319862	63.89230698805589	35.19551570598896					
			306	21.54593047908708	9.648051698223439	51.92309363371407	43.30712522868237	39.18644014059328					

Pomocníka, stlačte kláves F1.

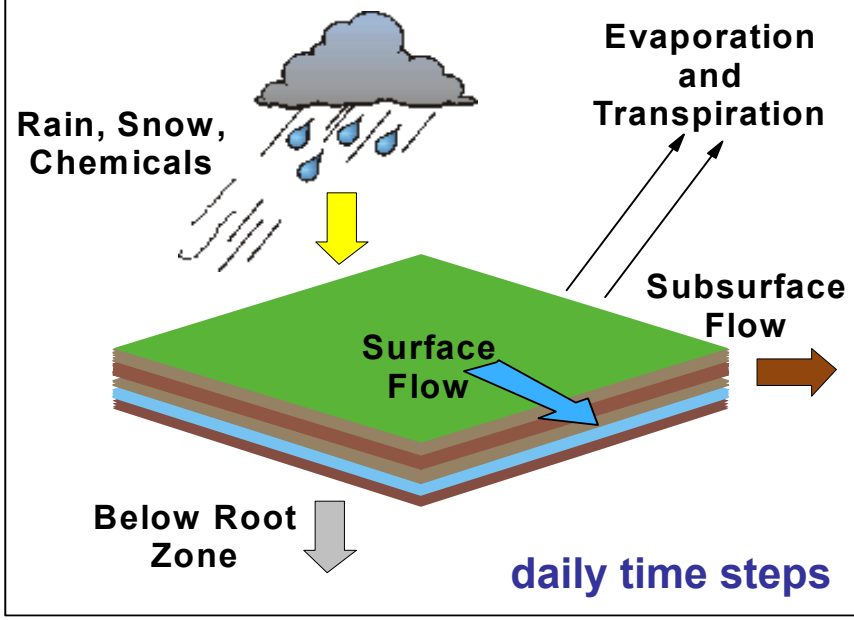
GIS Output Dataset: parameters specific for NUTS2 and Land categories

PTF (Hyprese, pH, BD ...)

Weather, Crop Rotation and Management

Processing in MS ACCESS

EPIC



105_OUT : Tabulka

NUTS2	LandCat	km2	cec_top	cec_sub	bs_top	bs_sub	sand_top	sand_sub
105	312	21	24.866314570	9.6612142381	42.934194565	36.763094947	39.936071487	37.72744769
105	312	3	21.578499476	15.429499944	73.449999491	56.933331807	26.861666997	13.79166666
105	312	354	24.621405149	11.310261004	45.33192397	38.559831080	36.233615999	32.78372362
105	312	22	23.966172739	24.50856619	78.97833252	71.273363980	15.086613568	12.32949869
105	312	115	20.963018343	9.0293946888	48.693839894	40.522273885	43.162296693	38.61363472
105	312	1786	25.544020638	11.17894459	44.319180638	38.169780074	32.201617546	30.39716941
105	312	83	22.710979439	25.819338810	84.058765733	74.439621450	13.168186039	12.43919214
105	313	7	19.780800547	13.915457453	69.028398786	59.471430097	30.465000425	20.15472848
105	313	102	22.432390475	10.52935691	50.012915967	41.384314107	36.96816192	34.35965562
105	313	61	15.540663813	11.946462381	80.559909363	67.476638544	39.914413077	16.34722780
105	313	755	20.700158507	9.9816509967	54.491654731	44.986298891	38.398761271	31.27707497
105	313	1	25.964399338	28.338499069	84.067199707	74.625	8.6374998093	
105	313	21	14.453571456	9.5878574281	83.587142944	70.247617812	51.552143279	13.47748547
105	313	663	25.027254325	12.531806232	50.645436993	43.504592073	30.772962147	29.32600473
105	313	20	24.302835083	27.57282991	84.751170349	74.790000153	9.9676971436	9.72638711
105	311	13	16.645238583	10.549253831	60.266245328	62.107693012	49.776923546	48.8478235
105	311	286	18.420135848	13.149598802	71.353143479	69.275961776	35.26678959	32.32374522
105	311	29	17.005296214	11.757117173	76.570731327	64.131033273	37.296896441	17.88850652
105	311	163	17.862403671	13.855626586	70.408396504	58.596779291	31.475291884	25.91631005
105	311	6	16.105499903	10.015000343	83.666666667	70.399998983	45.25333341	10.79166634
105	311	50	24.368940086	16.210789909	63.798102188	56.728999939	24.840338497	25.10447204
105	21	82	17.384600244	12.537791495	67.426865229	64.831098045	42.713262442	40.09058417
105	21	467	17.430952613	13.742183246	71.798535504	68.56638132	34.762275668	31.31813553
105	21	63	14.169271287	11.393312727	81.764205845	69.261904156	39.749523647	17.31178571

Záznam: 1 z 54

EPIC INPUT DATABASE for soil and topographic parameters

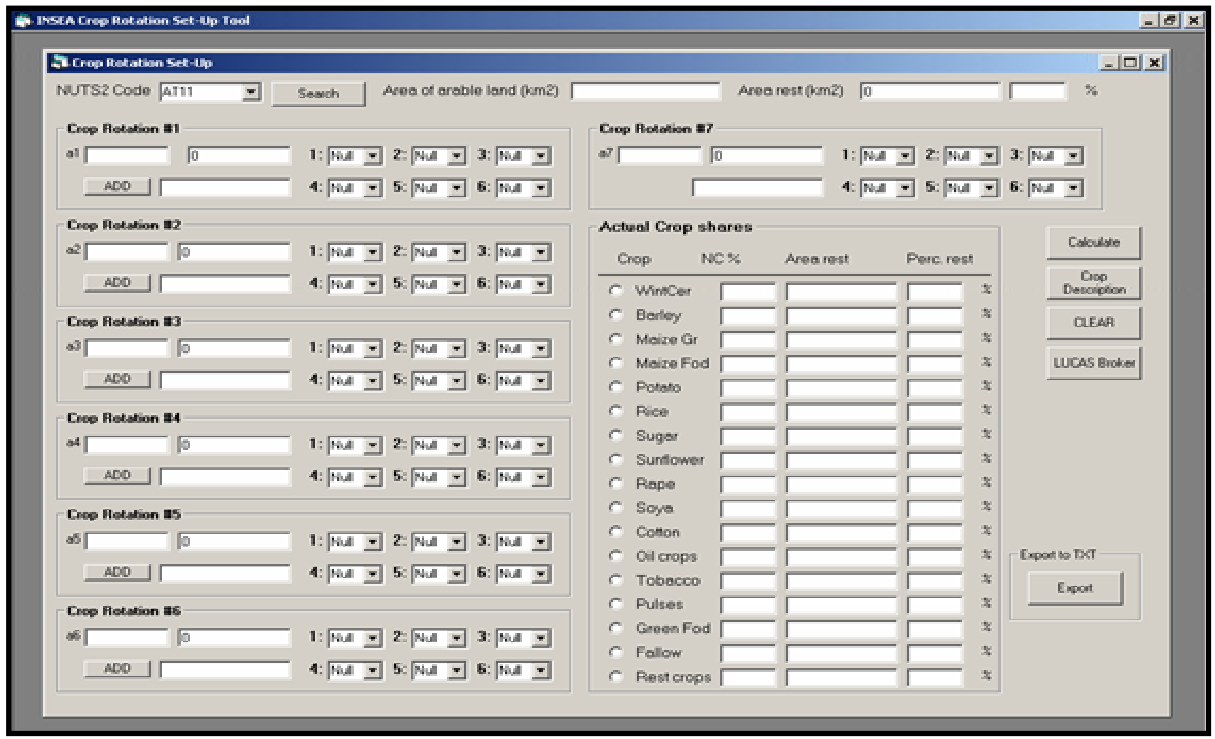
EPIC Simulations

Crop Rotation Setup:

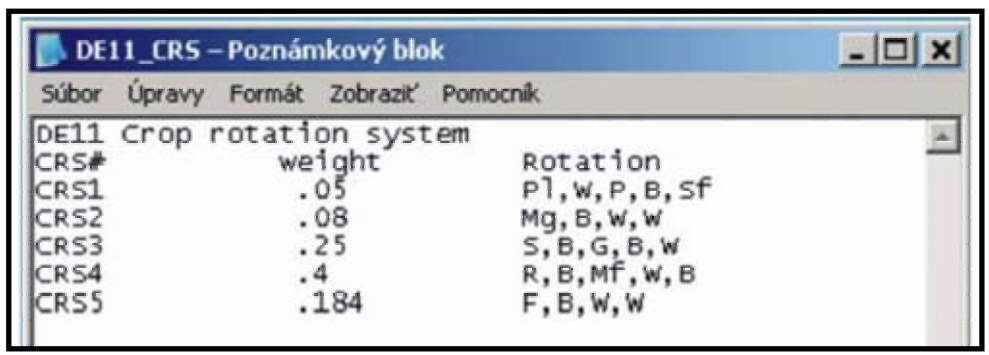
NEW CRONOS
Crop shares

Broken NC data
Crop shares

CORINE Data
Area of arable land
+ Hetero agric. area

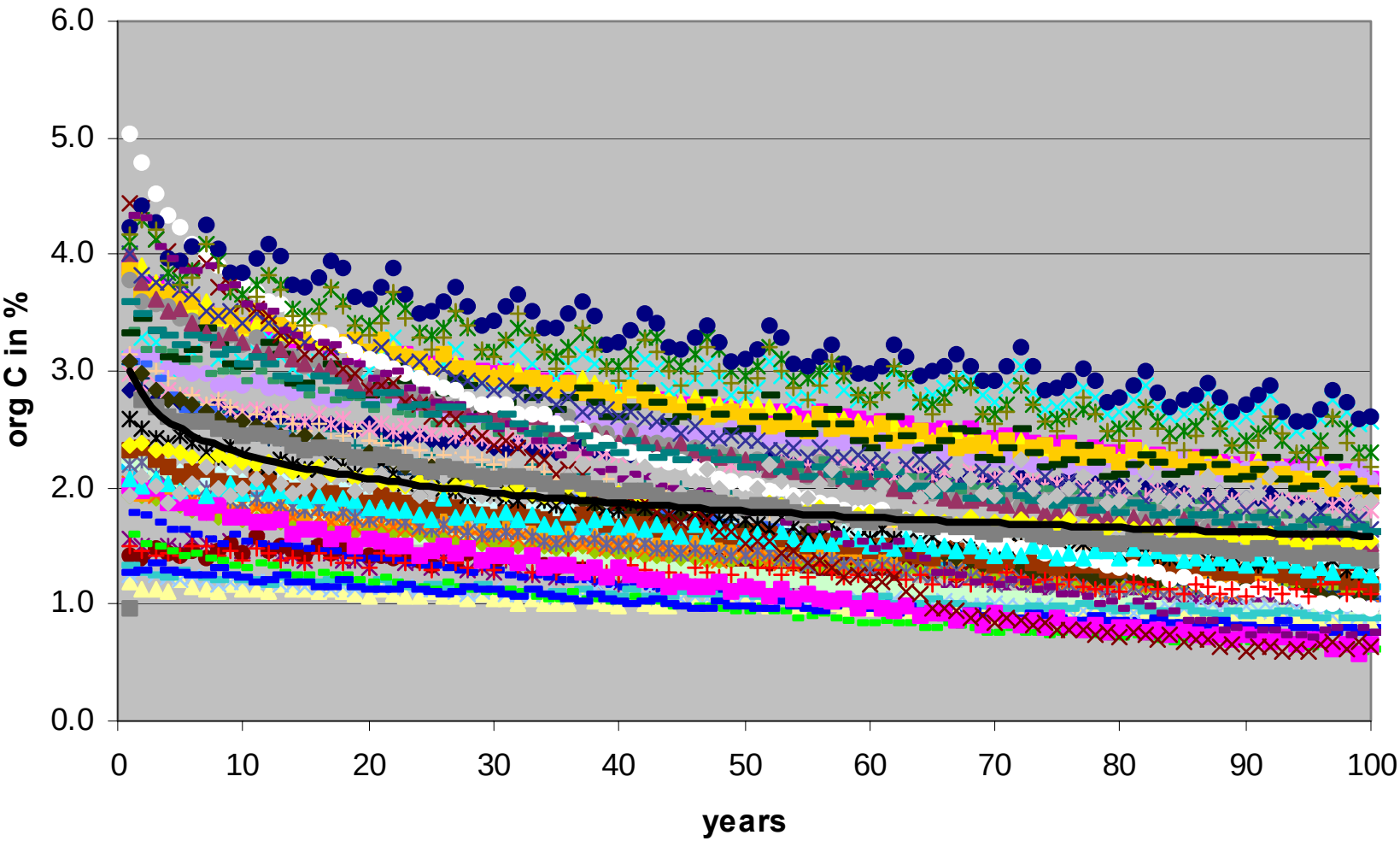


Crop rotation systems



Input Validation:

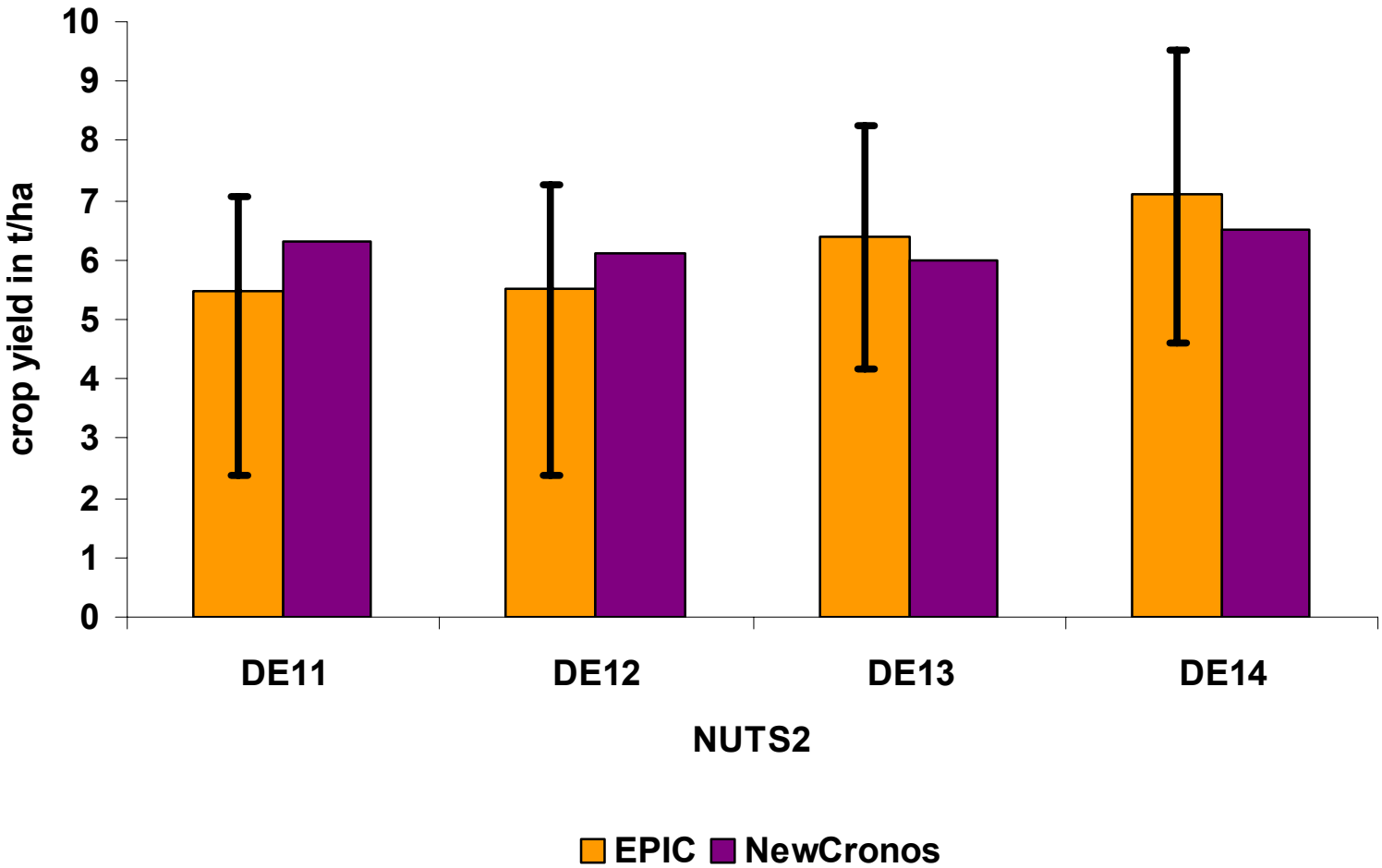
SOC at Plow Depth (15cm) using Initial SOC from ESDB v.1.2



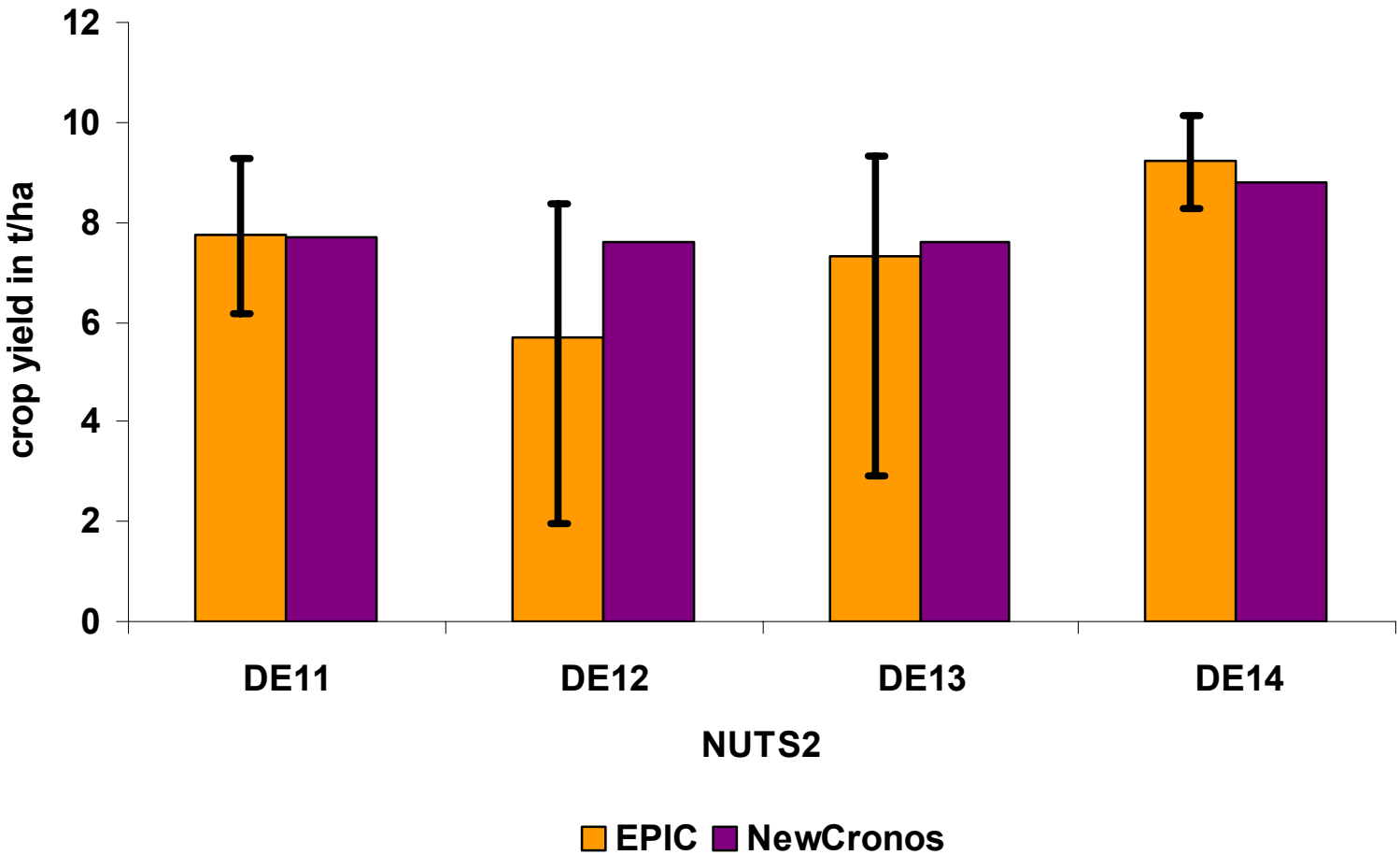
Output Validation:

Base-run Crop Yields: Winter Wheat

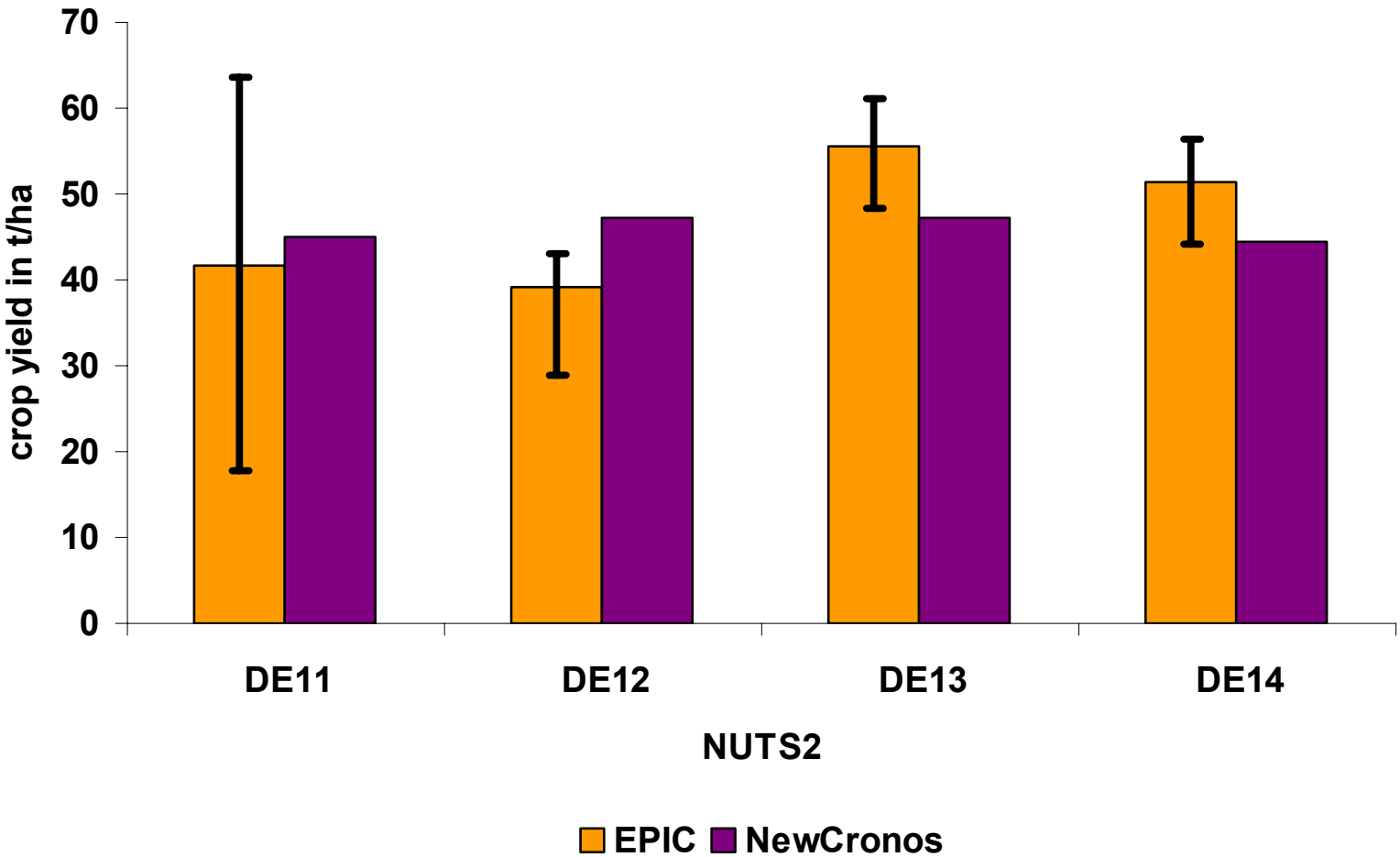
(averages and ranges of 10 yr simulation)



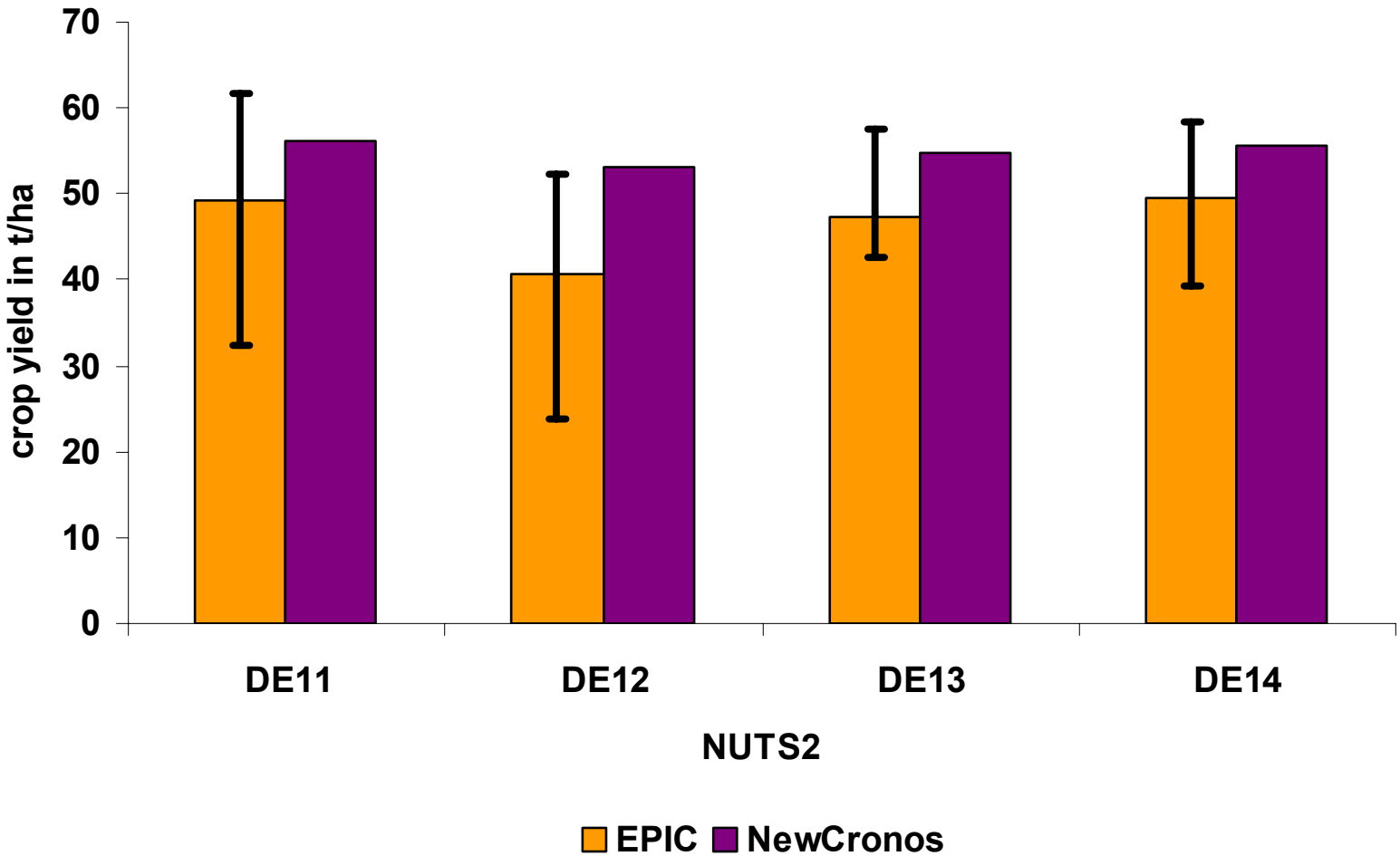
Base-run Crop Yields: Maize Grain
(averages and ranges of 10 yr simulation)



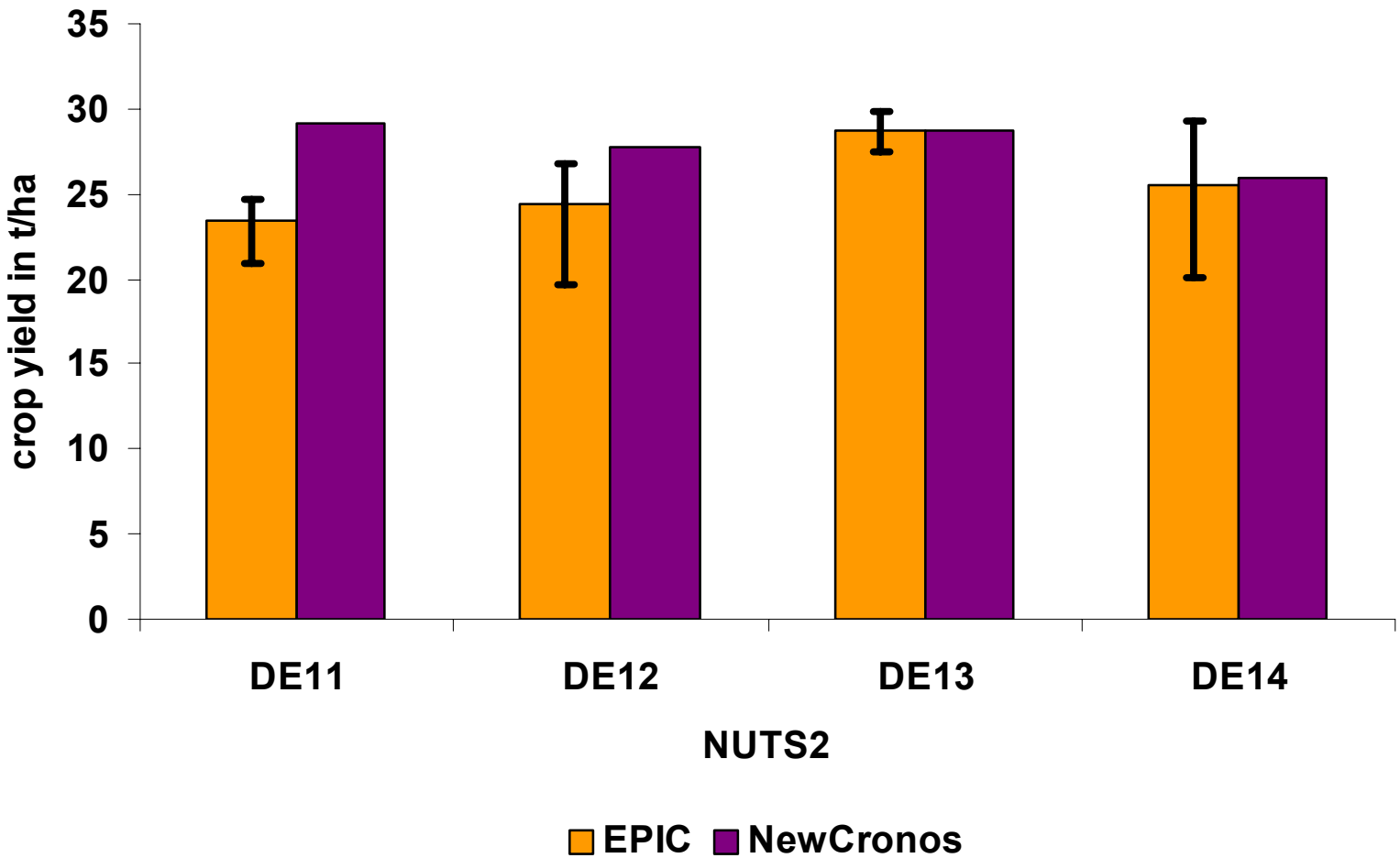
Base-run Crop Yields: Maize Silage
(averages and ranges of 10 yr simulation)



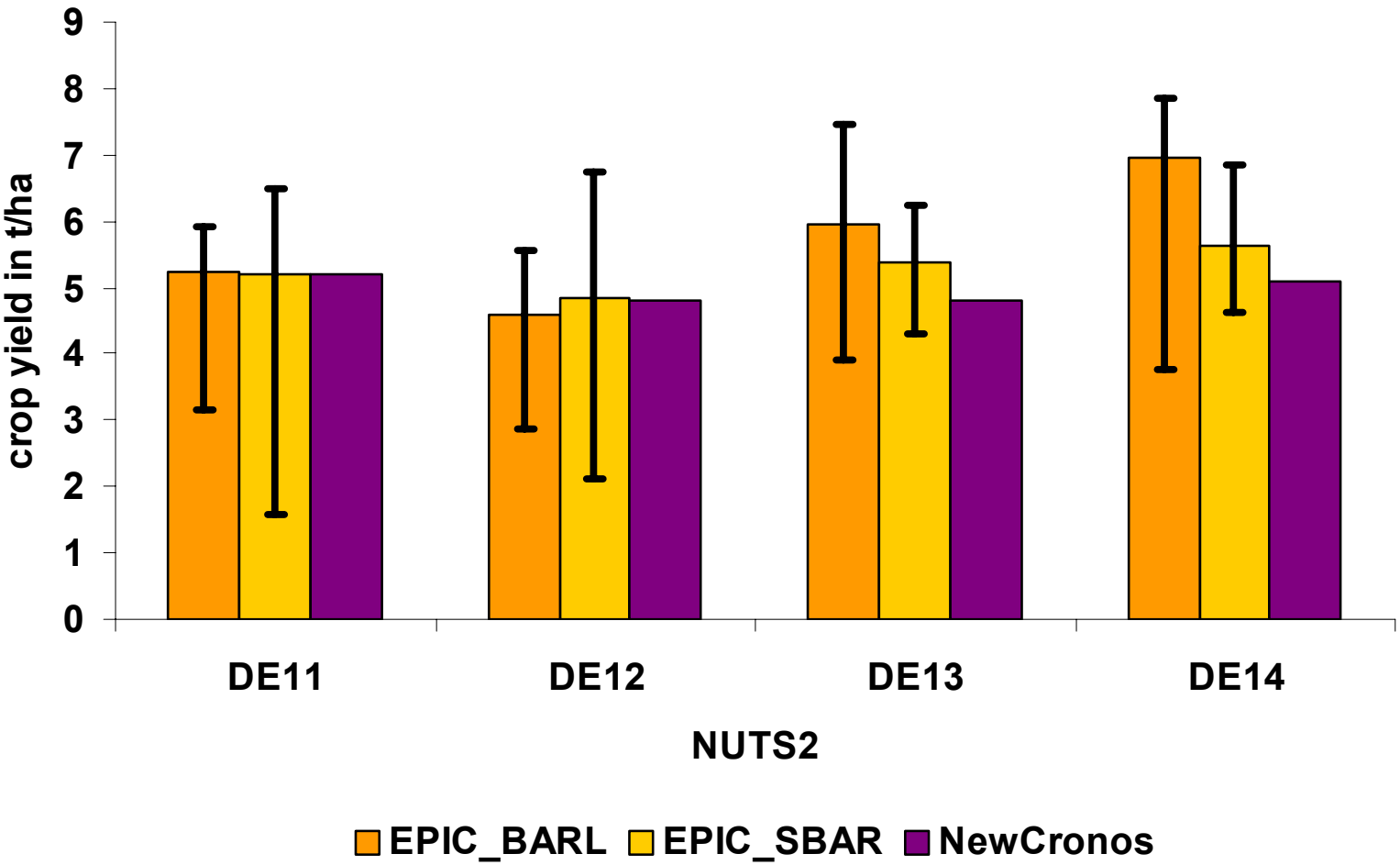
Base-run Crop Yields: Sugar Beet
(averages and ranges of 10 yr simulation)



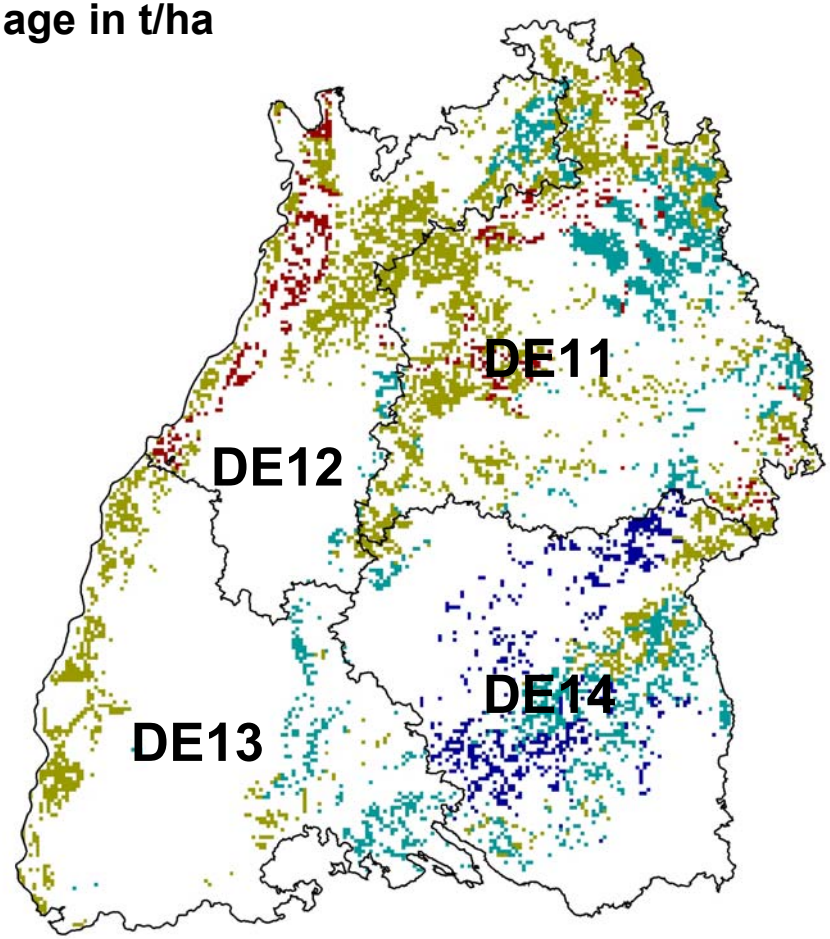
Base-run Crop Yields: Potatoes
(averages and ranges of 10 yr simulation)

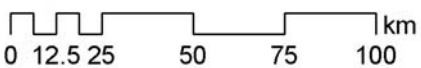


Base-run Crop Yields:
Winter (BARL) and Spring Barley (SBAR)
(averages and ranges of 10 yr simulation)

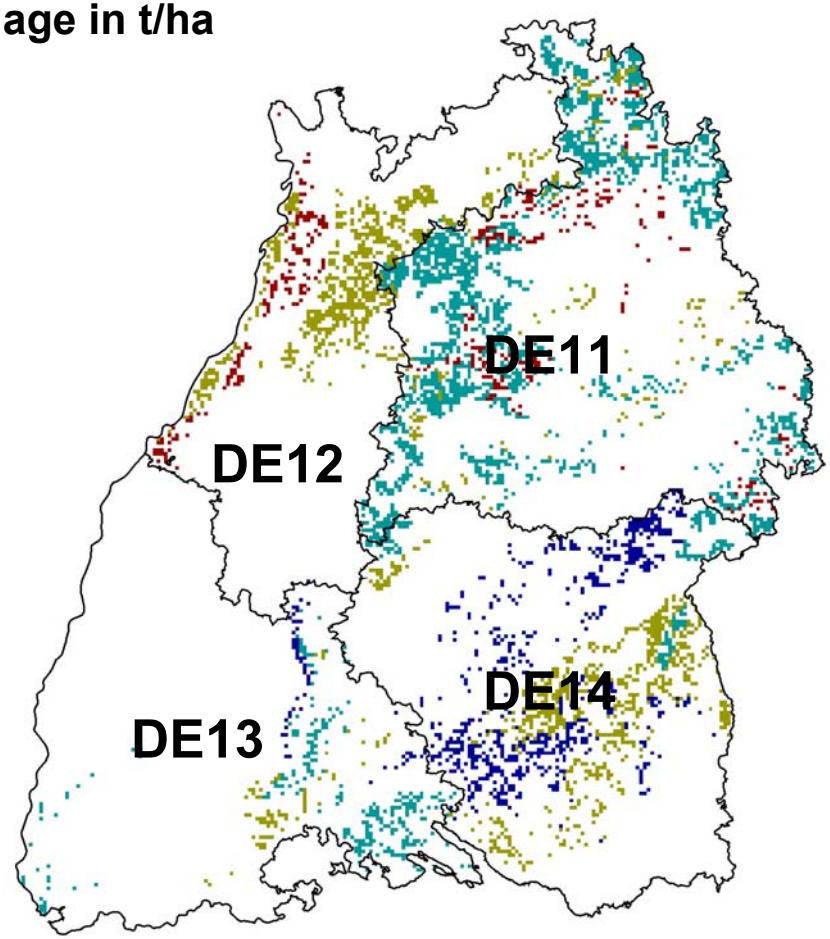


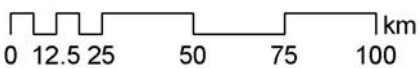
Average Winter Wheat Yields from conventional tillage in t/ha

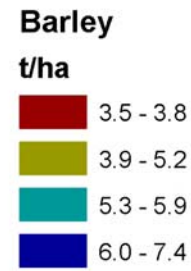




Average Winter Barley Yields from conventional tillage in t/ha

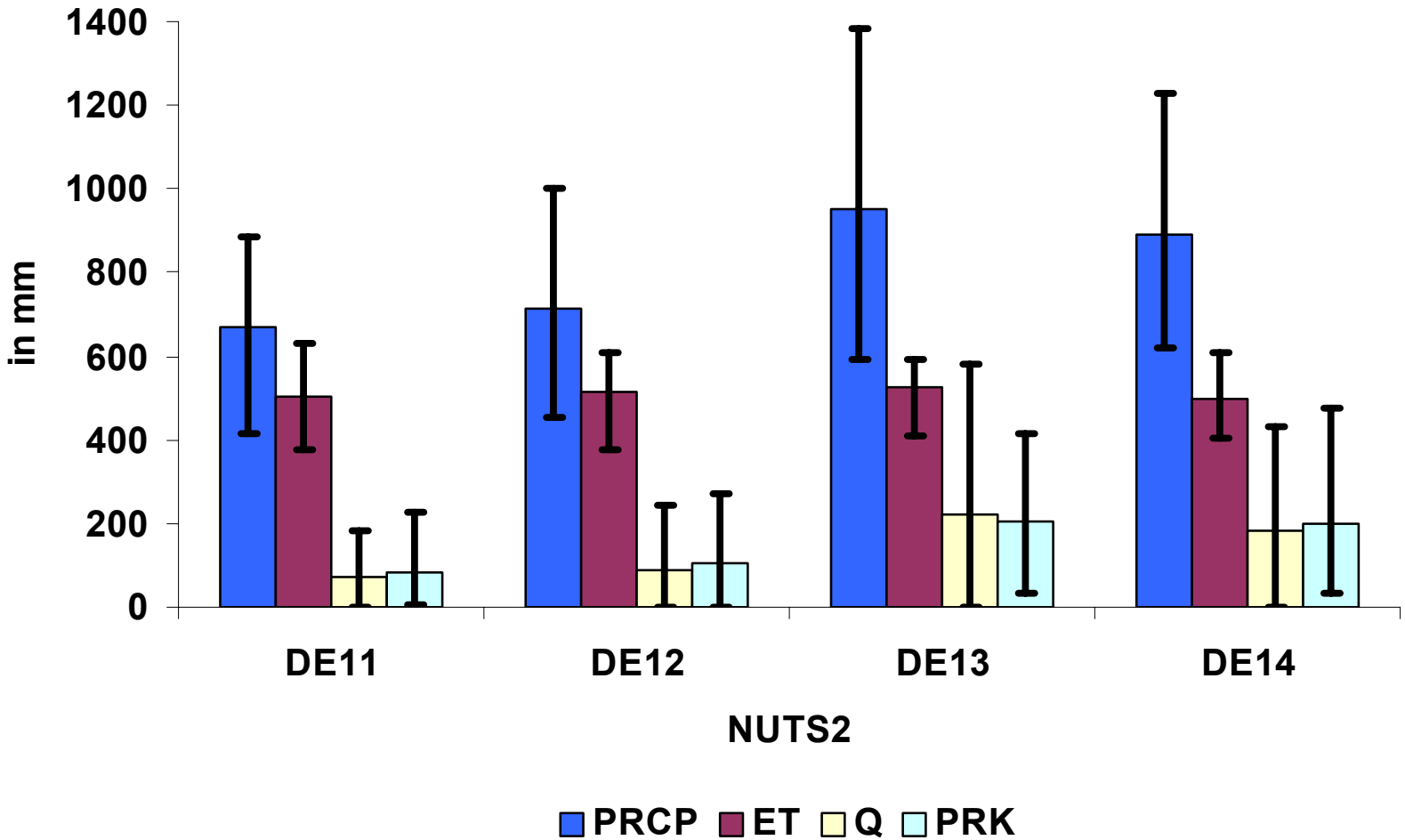




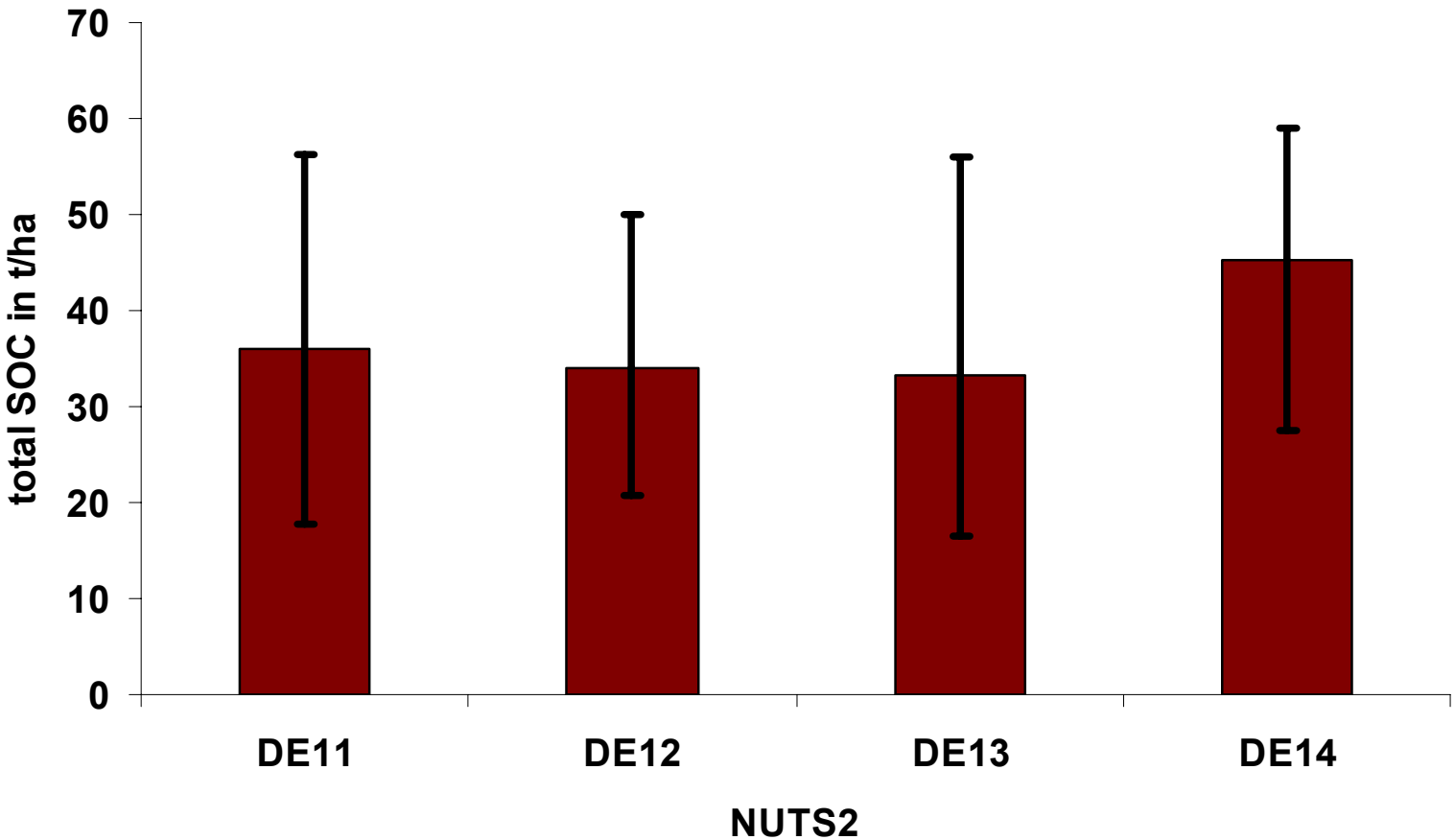


Annual Rainfall (PRCP), Evapotranspiration (ET), Runoff (Q), and Percolation (PRK)

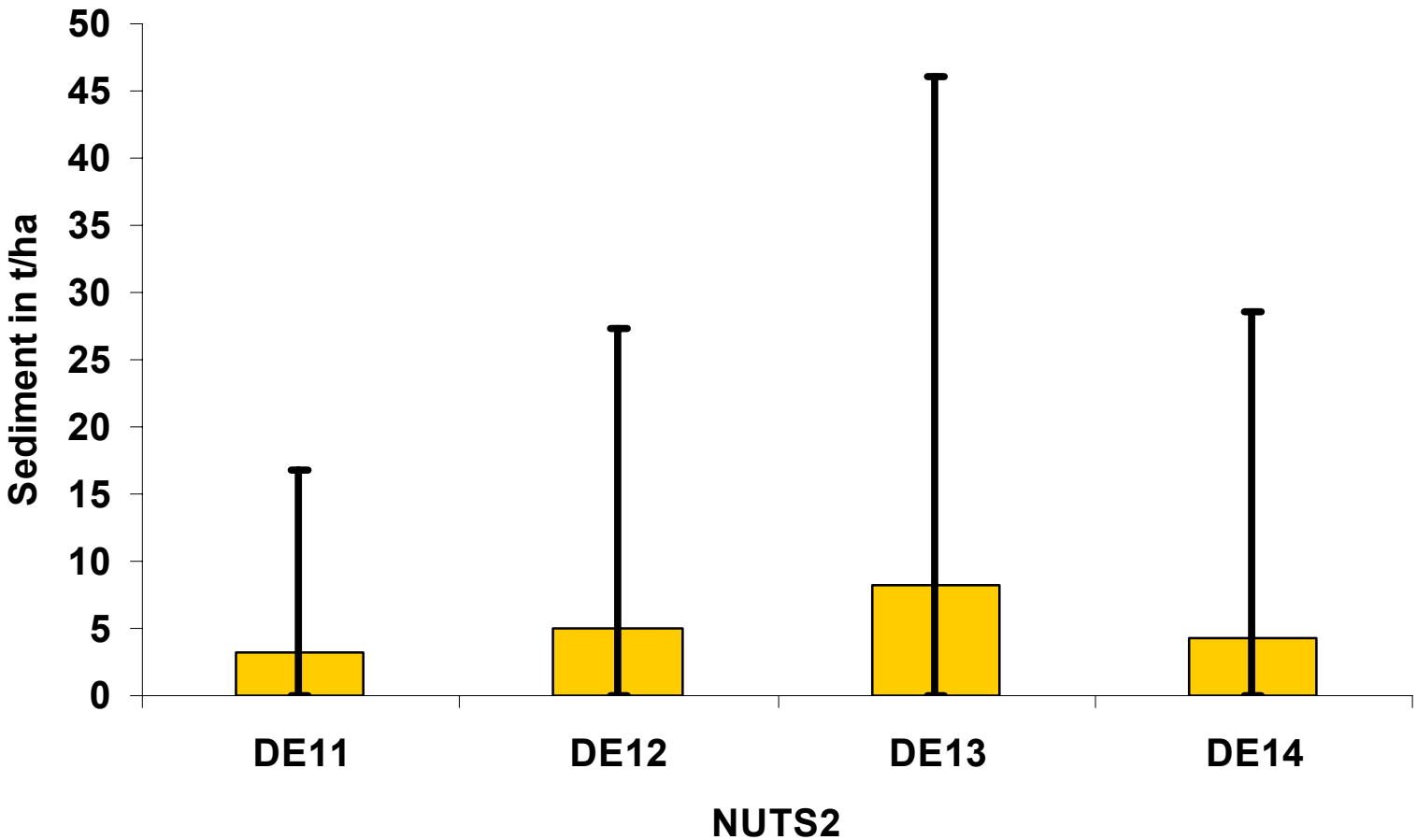
(averages and ranges of 10 yr simulation)



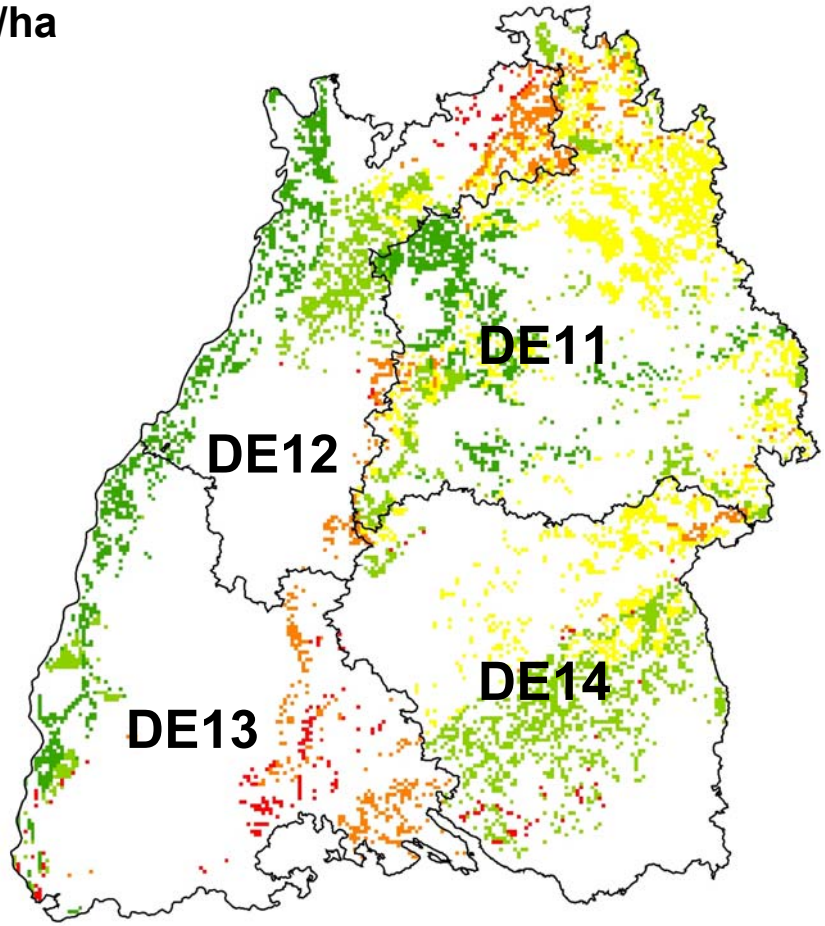
Base-run: Total SOC
(averages and ranges of 10 yr simulation)

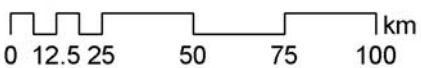


Base-run: Sediment Yield
(averages and ranges of 10 yr simulation)

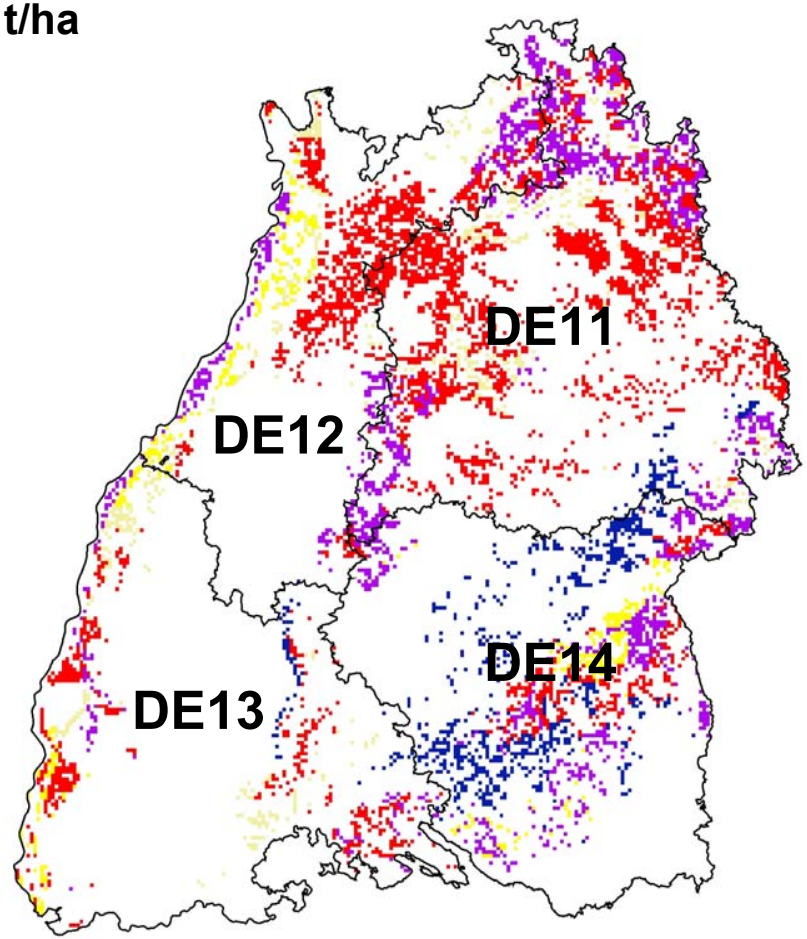


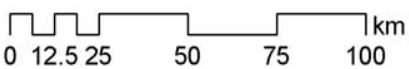
Average Sediment Yields from conventional tillage in t/ha





Average SOC from conventional tillage in t/ha





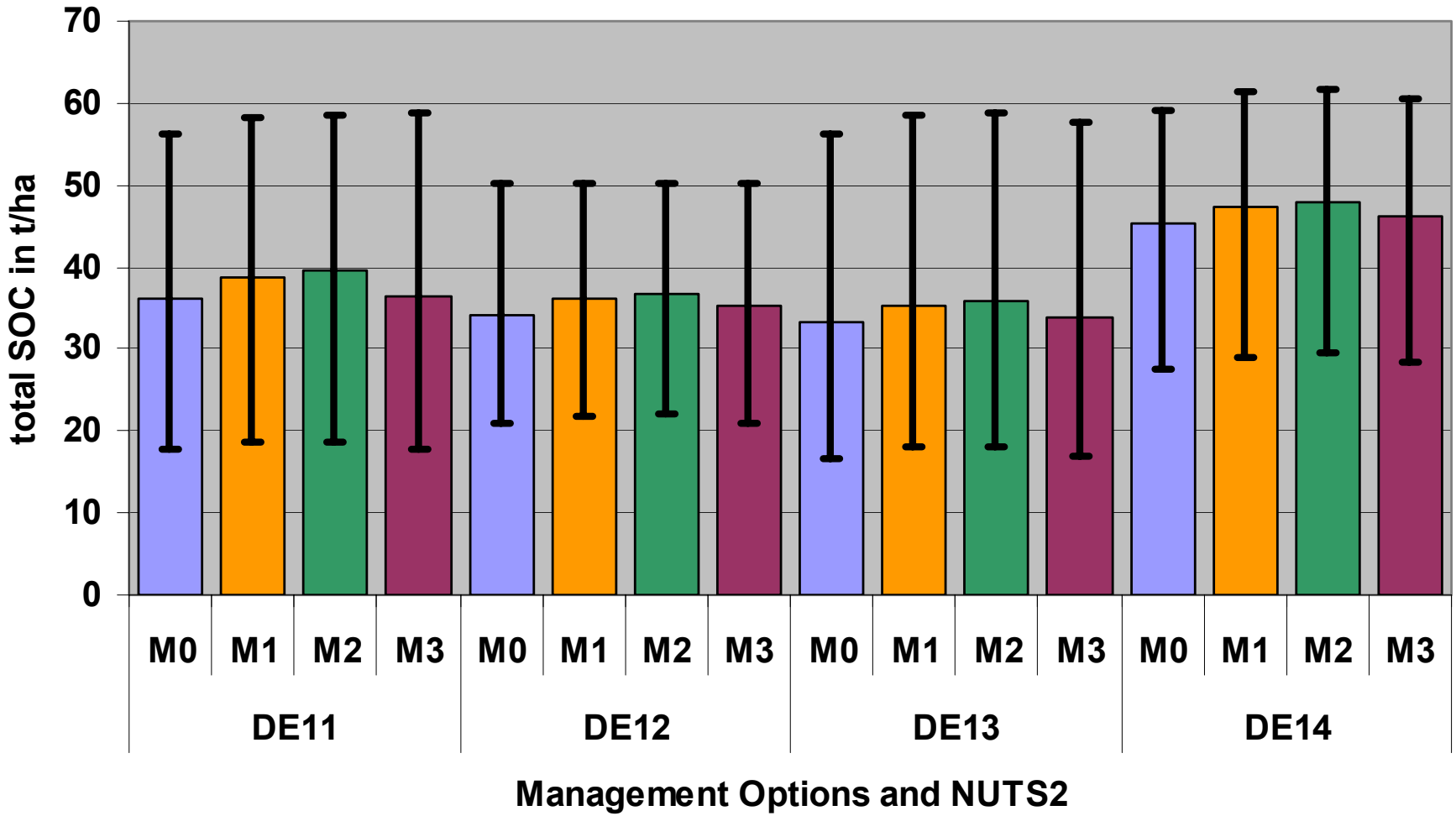
Alternative Management Practices (Crop Residue Management)

- **M0: base-run**
  conventional tillage (mold board plow; <15% crop residue)
- **M1: reduced tillage (disk or chisel plow; 15-30% crop residue)**
- **M2: minimum tillage (light disk plow; >30% crop residue)**
- **M3: conventional tillage with winter cover crops**

Definition of Crop Residue Management (CRM) according to the Conservation Technology Information Center (CTIC)
http://www.ctic.purdue.edu/CTIC/Catalog/CropResidueManagement.html

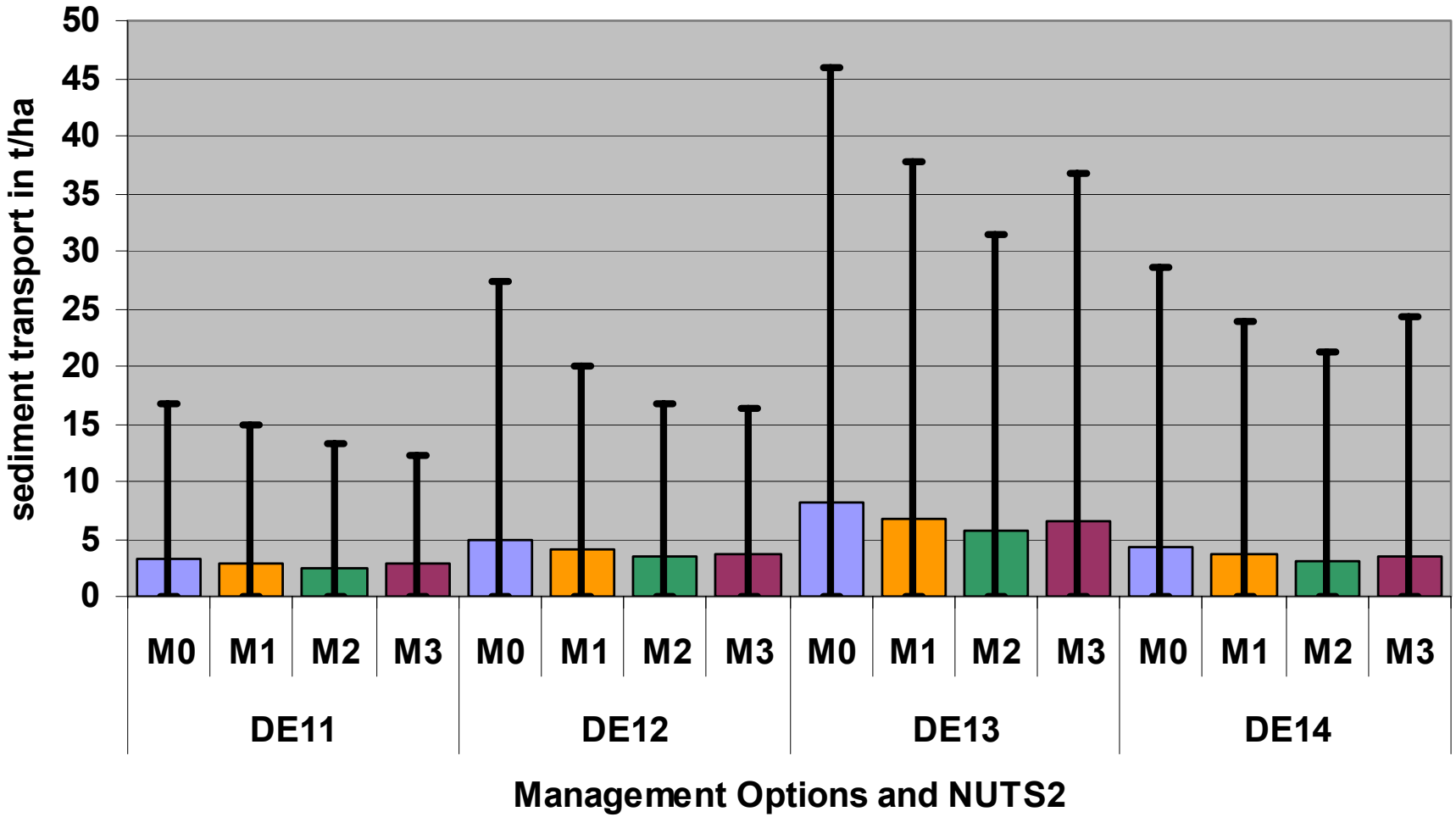
Impact of Alternative Management Practices on Total SOC

(averages and ranges of 10 yr simulation)



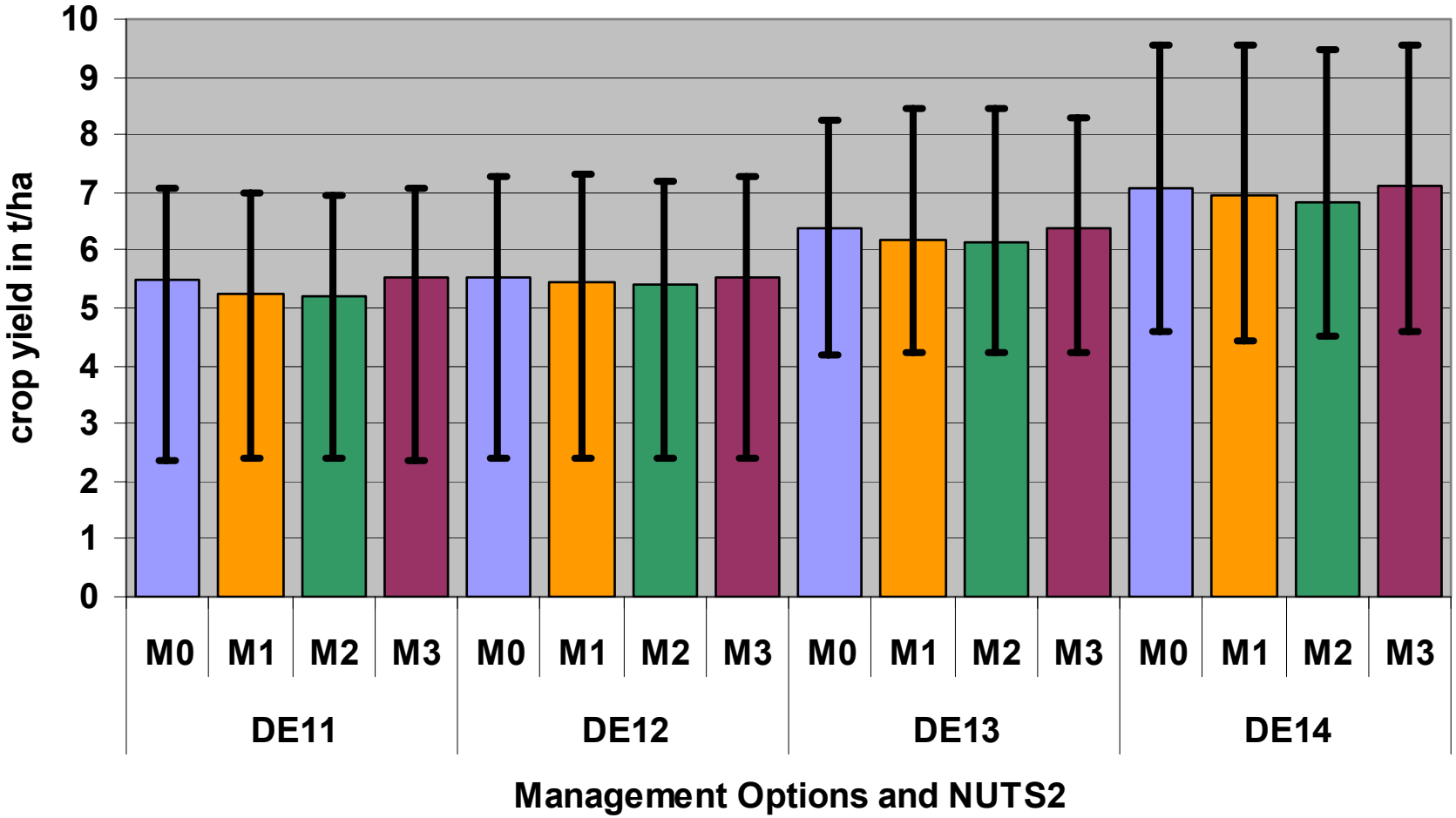
Impact of Alternative Management Practices on Sediment Yield

(averages and ranges of 10 yr simulation)

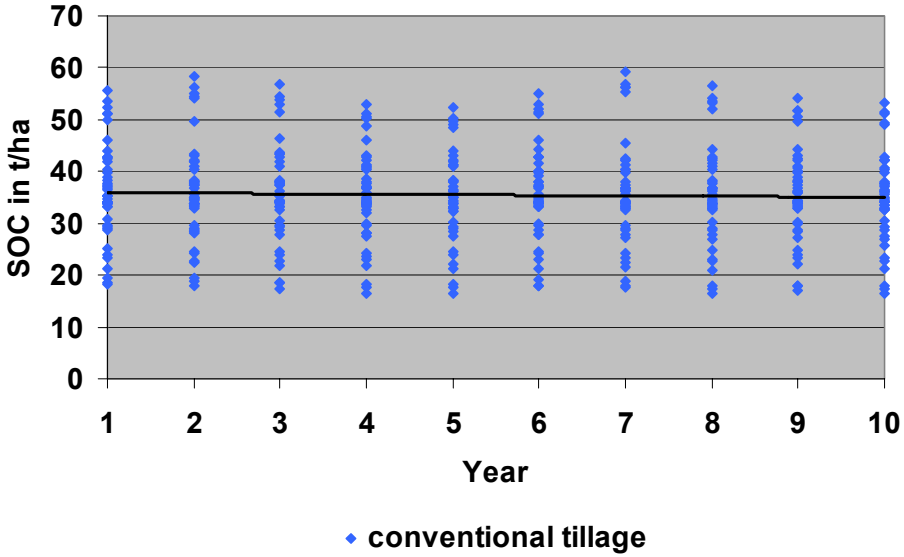


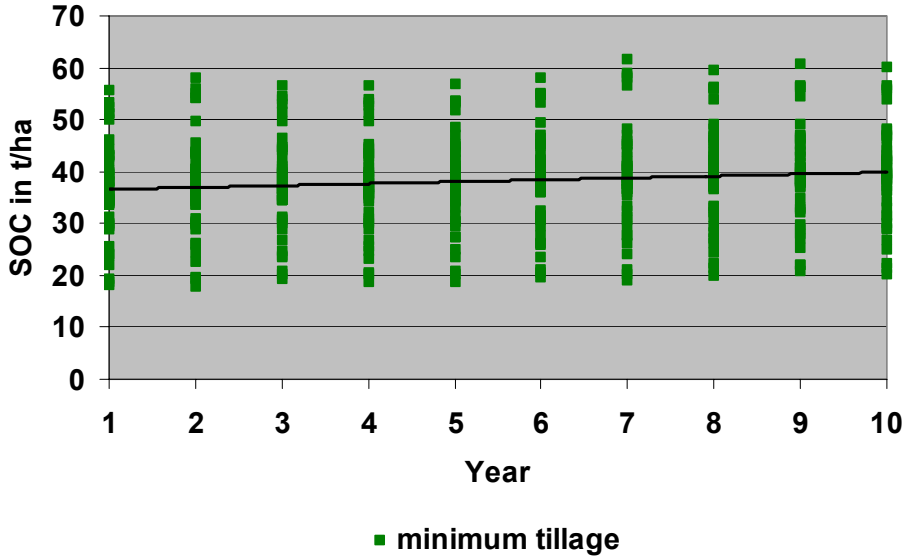
Impact of Alternative Management Practices on Winter Wheat Yield

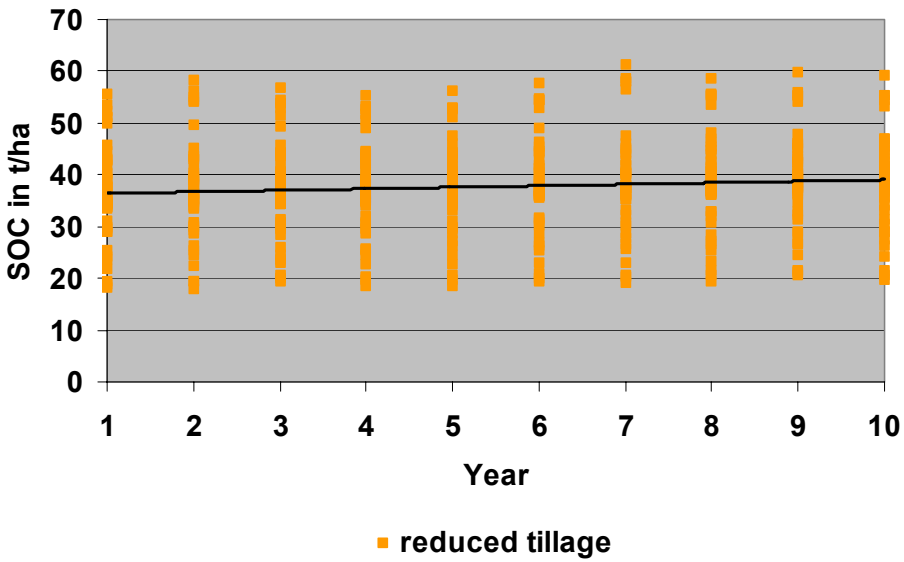
(averages and ranges of 10 yr simulation)

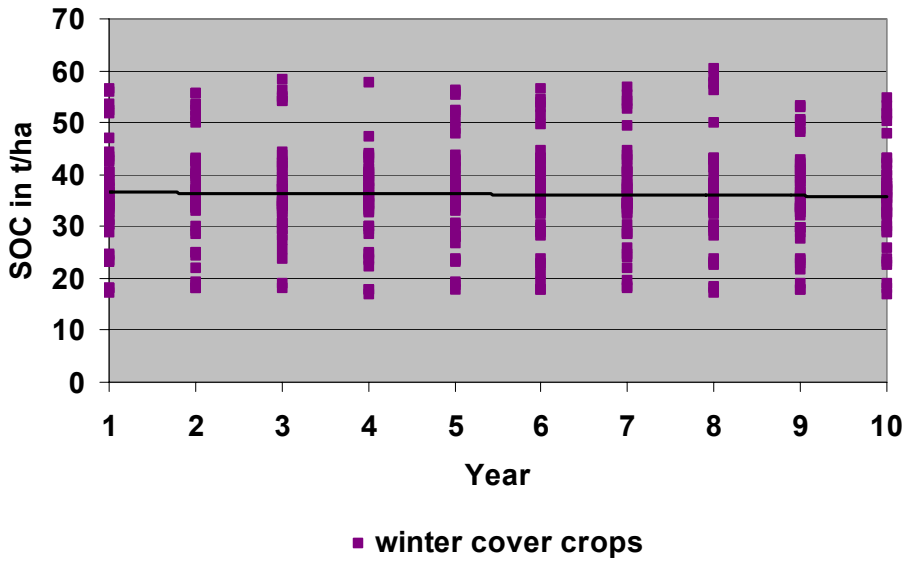


Trends in Total SOC

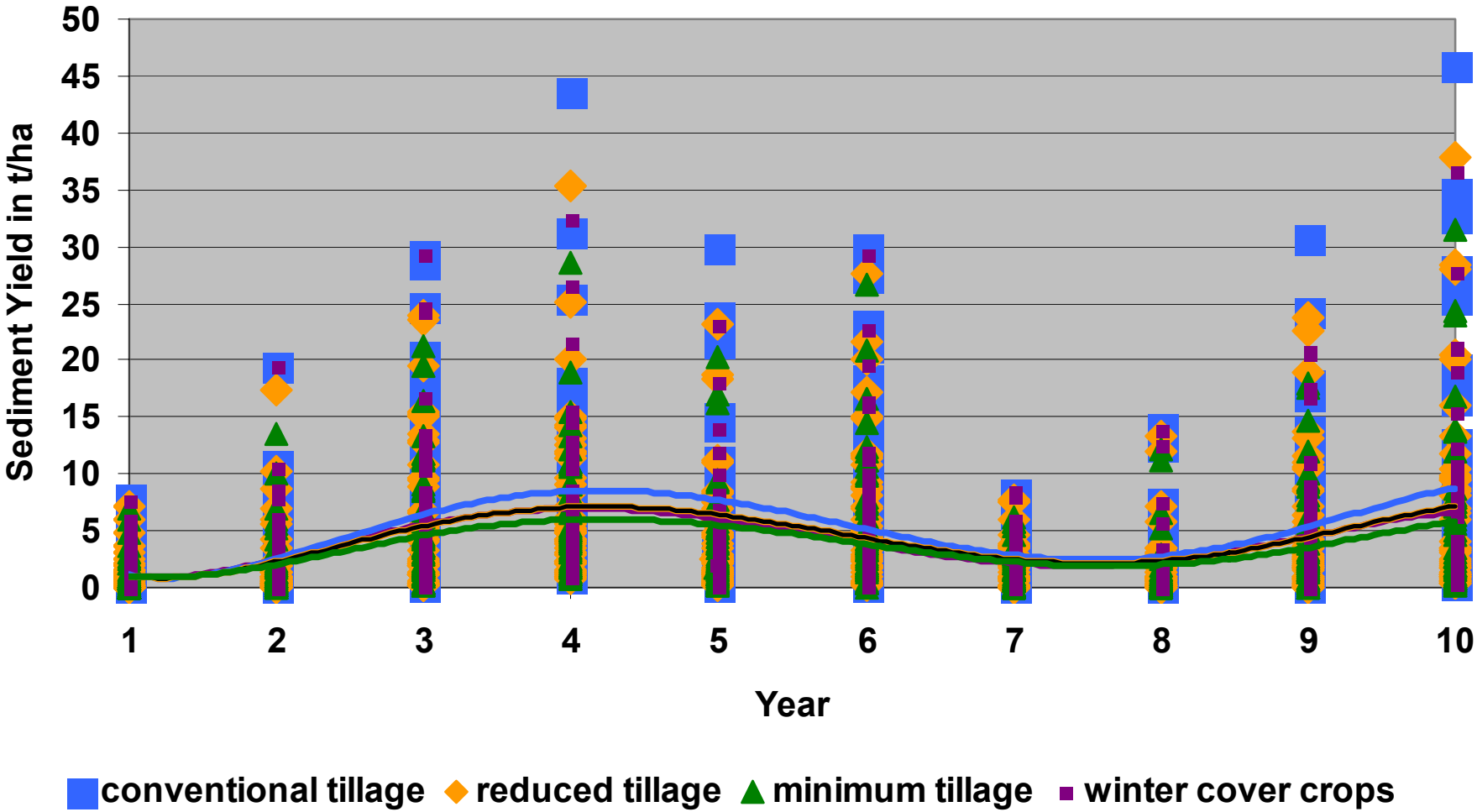




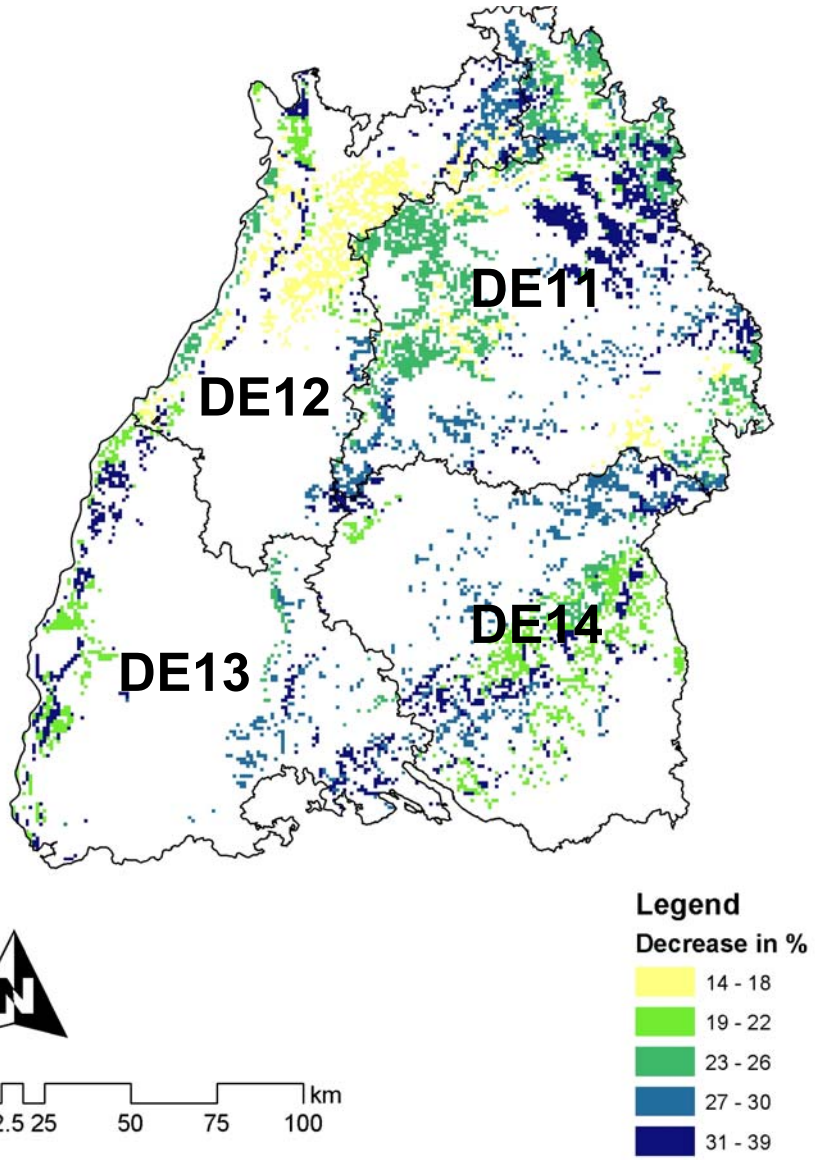




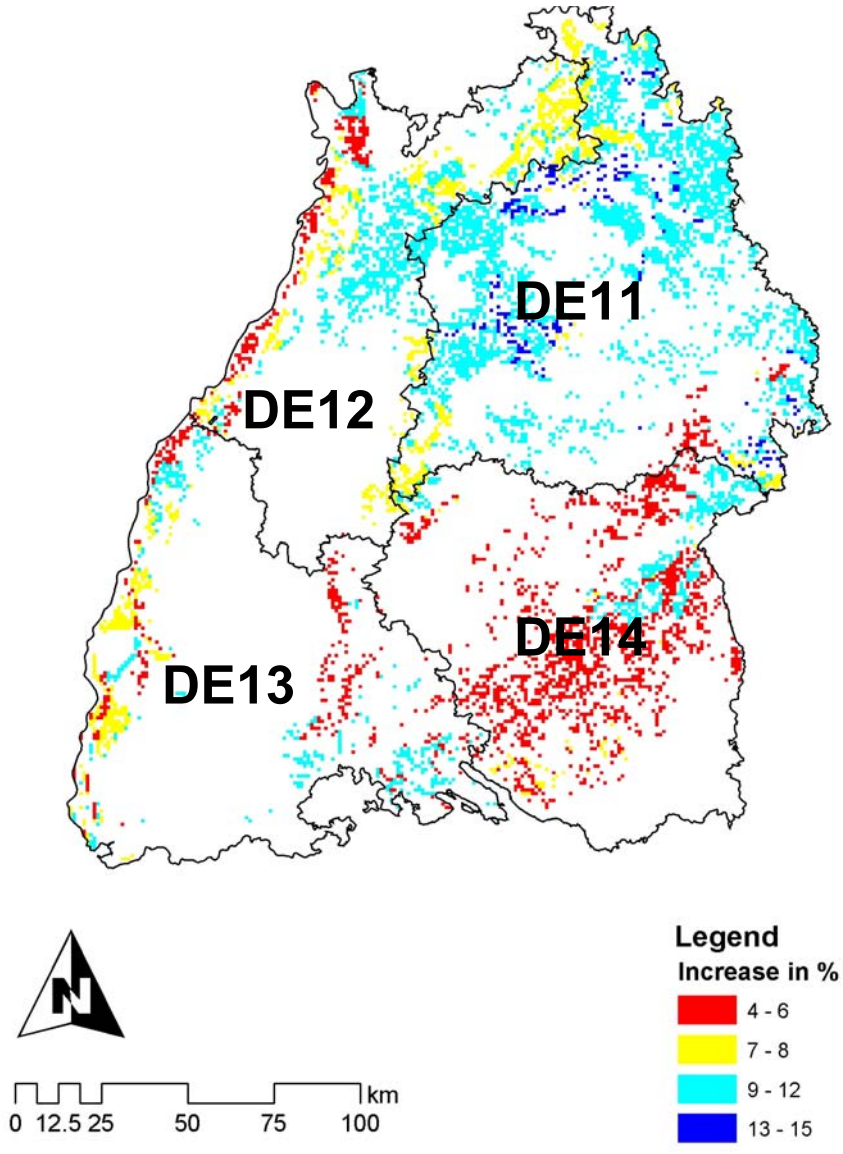
Annual Sediment Yields



Potential reduction in Sediment Yield when changing from conventional to minimum tillage in %



Potential SOC sequestration when changing from conventional to minimum tillage in %



Model Output Presentation with Output Response Functions

Regression Model (OLS) using Dummy Variables

$$Y = \beta_0 + \beta_1 M_1 + ,..., + \beta_3 M_3 + \varepsilon$$

where M_1,..., M_3 are alternative management practices that are represented by dummy variables (0,1)

Management Impact on Crop Yields, Sediment Yield, and SOC

Production Indicators

	Unit	β_0	β_1	β_2	β_3
Winter Wheat	t/ha	5.9	-0.17	-0.23	+0.02
Sugar Beet	t/ha	47.0	-5.61	-8.37	-2.78
Corn	t/ha	6.8	-0.02	-0.41	-0.02
Corn Silage	t/ha	48.3	-1.80	-3.70	-1.06
Winter Barley	t/ha	5.6	-0.39	-0.44	-0.02
Spring Barley	t/ha	5.2	-0.34	-0.52	-0.09
Potatoes	t/ha	24.7	-0.21	-1.68	-0.15

Environmental Indicators

	Unit	β_0	β_1	β_2	β_3
Sediment Yield	t/ha	5.11	-0.81	-1.45	-0.96
SOC in Soil Profile	t/ha	35.5	2.26	2.76	0.71

Summary

- The developed HRU methodology environmental impact analyses with EPIC at EU scale using existing data and information systems.
- A gradual reduction in crop residue mixing using different tillage systems can reduce sediment yields by up to 30% and sequester SOC by up to 8% in average.
- An introduction of winter cover crops in crop rotation systems can reduce sediment yields by 20% and sequesters SOC by 2% in average.
- The impact of alternative management practices on crop yields can range between +1% and -18% in average.