Table S1. Compilation of data from our long-term experiment comparing no-tillage (NT) and conventional tillage (CT) under crop rotation R2 (black oat/soybean/black oat + common vetch/maize/oilseed radish /wheat/soybean).

Attribute	Unit	Age (years) or period of experiment	Soil depth (cm)	NT	CT
Carbon and nitrogen inputs to the soil, soil stocks and nitrogen balance					
[1] Average annual C input (aboveground+30% root contrib.)	Mg ha^{-1} $year^{-1}$	Jun 1999–Jun 2001	-	4.1	3.3
[2] Average annual aboveground C input Soybean/wheat/oat/maize/oat+vetch/oilseed radish	Mg C ha^{-1} $year^{-1}$	1985–2007	-	2.9/1.6/2.5/4.7/2.9/1.5	2.5/1.4/2.1/3.8/2.6/1.5
[2] Average annual aboveground C input	Mg C ha^{-1} $year^{-1}$	1985–2007	-	6.1	5.3
[3] Average annual N input by crops + mineral fertilization	Mg ha^{-1} $year^{-1}$	1985–2004	-	0.079	0.076
[4] Average annual above ground N input (cover crops)	Kg ha^{-1}	1998–2000	-	233	224
[3] Average C/N of residues (incl. mineral N fertilization)	-	1985–2004	-	78.4	70.3
[2] SOC stock	Mg ha^{-1}	22	0–5/5–15/15–30	15.7/22.9/34.4	10.5/25.4/30.4
[2] SOC stock	Mg ha^{-1}	22	30–45/45–60/60–90	24.3/19.5/26.5	22.7/19.2/26.0
[5] Total N stock	Mg ha^{-1}	22	0–30/0–100	6.5/13.8	5.1/12.1
Nitrogen balance = (maize+wheat mineral nitrogen fertilization) – (maize+wheat+soybean grain exportation)	Kg ha^{-1}	22	-	-2639	-2017
Soil organic matter protection mechanisms					
[3] Particulate organic C stock	Mg ha^{-1}	19	0–5/5–10/10–20/20–30	3.2/0.7/0.5/0.3	1.9/1.1/0.9/0.3
[3] Mineral associated organic C stock	Mg ha^{-1}	19	0–5/5–10/10–20/20–30	14.6/11.8/20.9/19.4	12.9/11.8/20.5/18.5
[3] Particulate total N	Mg ha^{-1}	19	0–5/5–10/10–20/20–30	0.23/0.06/0.05/0.03	0.12/0.09/0.08/0.02
[3] Total N associated to minerals	Mg ha^{-1}	19	0–5/5–10/10–20/20–30	1.3/0.9/1.6/1.5	1.0/0.9/1.6/1.4
[3] Particulate organic matter fraction C/N ratio	-	19	0–5/5–10/10–20/20–30	14.2/12.2/8.5/10.3	16.0/13.2/11.5/13.9
[3] Mineral associated organic matter fraction C/N ratio	-	19	0–5/5–10/10–20/20–30	11.8/12.6/13.0/13.0	12.6/12.5/12.7/13.3
[1] C management index	-	19	0–30	158	130
[2] C content in aggregate classes <53/53–250/250–2000/ >2000 μm	g 100 g^{-1} fraction	22	0–5	4.0/3.7/3.1/3.6	2.4/2.7/2.3/2.5
[6] C groups in humic acids in aggregates (150–250 μm) Carboxyl/Aromatic/O-alkyl/Alkyl	%	27	0–5	7.6/50.6/21.3/20.5	1.4/35.2/31.2/23.2
[6] Humic acids hydrophilic/hydrophobic C	%	27	0–5	59.8/40.2	71.3/28.7
Physical attributes					
[7] Aggregate classes <53/53–250/250–2000/ >2000 μm	g 100 g^{-1} soil	22	0–5	0.7/2.2/10.9/86.2	0.8/2.4//12.7/84.2
[8] Geometric mean diameter of aggregates	mm	7	0–5	2.23	1.38
[2] Soil bulk density	Mg m^{-3}	22	0–5/5–10/10–15/15–20	1.1/1.3/1.4/1.4	1.2/1.2/1.2/1.3

Soil microbiota and enzyme activity					
[9] Microbial biomass	nmol g^{-1} soil	32	0–5/5–10/10–30	44.2/23.0/12.4	28.2/26.3/18.8
[9] Total bacteria	nmol g^{-1} soil	32	0–5/5–10/10–30	16.5/10.0/5.8	11.9/11.3/8.4
[9] Total fungi	nmol g^{-1} soil	32	0–5/5–10/10–30	9.6/5.5/2.3	6.4/5.9/3.9
[9] Actinomycetes	nmol g^{-1} soil	32	0–5/5–10/10–30	1.6/1.2/0.7	1.2/1.2/0.9
[9] Arbuscular mycorrhizal fungi	nmol g^{-1} soil	32	0–5/5–10/10–30	6.3/4.0/1.8	4.3/4.1/3.0
[9] B-glucosidase	$nmol^{-1}$ hr^{-1} g^{-1} soil	32	0–5/5–10/10–30	301.0/95.7/63.6	76.1/65.4/48.7
[9] N-acetyl-glucosaminidase	$nmol^{-1}$ hr^{-1} g^{-1} soil	32	0–5/5–10/10–30	139.7/141.5/133.5	62.2/67.0/96.4
CO_2-C flux, residues decomposition and C sequestration rate					
[10] Annual CO_2-C efflux	Mg ha^{-1}	1999–2001	-	9.5	8.9
[10] $t_{1/2}$ black oat+vetch residues	Day	Nov 1998–Apr 1999	-	124	54
[10] $t_{1/2}$ wheat residues	Day	Nov 1999–Apr 2000	-	177	82
[11] Average CO_2-C emission	Kg ha^{-1} day^{-1}	Sep–Oct 2007	-	28.0	48.1
[12] Average CO_2-C emission	Kg ha^{-1} day^{-1}	May – Sep 2010	-	24.4	-
[2] Average apparent C sequestration rate	Mg ha^{-1} $year^{-1}$	1985–2007	0–30/0–60/0–90	0.38/0.48/0.52	0.07/0.08/0.09
Crop yields					
Average yield (soybean/maize)	Kg ha^{-1}	1985–2007	-	3064/6082	2461/5089

[1] Campos et al. [39], [2] Nicoloso [38], [3] Campos [60], [4] Ferreira et al. [11], [5] Nicoloso et al. [41], [6] Arachchige et al. [27], [7] Fiorin et al. [45], [8] Campos et al. [37], Pires et al. [44], [10] Campos et al. [40], [11] Pes et al. [46], [12] Bortolotto et al. [61].

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Table S2. F-statistics (F), degrees of freedom (df) and probability values (*p*) for effects of tillage system (TS), cover crops (CC) and their interaction (TS x CC) on dry biomass (a), carbon (C) input by CC (b), nitrogen input by CC (c), daily average CO_2-C emission from the 28 measuring days (d), total accumulated CO_2-C emission during the 124 days (e), C in the CC biomass remaining in the litter-bags after 124 days (f), CC residues half-life time (g), and apparent C balance (h).

Response variables	TS		CC		TS x CC	
	F_{df}	*p*	F_{df}	*p*	F_{df}	*p*
Dry biomass[(a)]	$0.00_{1,18}$	0.955	$5.0_{2,18}$	0.0307	$0.65_{2,18}$	0.544
C input[(b)]	$0.01_{1,18}$	0.937	$10.8_{2,18}$	<0.0001	$1.17_{2,18}$	0.333
N input[(c)]	$0.12_{1,18}$	0.739	$610.3_{2,18}$	<0.0001	$0.31_{2,18}$	0.738
CO_2-C emission (28 days)[(d)]	$404_{2,36}$	<0.0001	$367_{3,36}$	<0.0001	$16.5_{6,36}$	<0.0001
CO_2-C emission (124 days)[(e)]	$123_{1,15}$	<0.0001	$16.1_{2,15}$	0.0002	$8.09_{2,15}$	0.0041
Remaining C (124 days)[(f)]	$189_{1,15}$	<0.0001	$106_{2,15}$	<0.0001	$4.35_{2,15}$	0.0323
CC half-life time[(g)]	$313_{1,18}$	<0.0001	$43.7_{2,18}$	<0.0001	$18.1_{2,18}$	<0.0001
Apparent C balance[(h)]	$68_{1,15}$	<0.0001	$5.01_{2,15}$	<0.0216	$7.43_{2,15}$	<0.0057

Table S3. Average soil temperature, moisture and water-filled space porosity (WFSP) as affected by soil tillage system: conventional tillage (CT), minimum tillage (MT) and no-tillage (NT) and cover crops: no cover crop (ncc), oat, oat+vetch and vetch. Values are means of 28 measuring days performed within the whole experimental period (124 days).

Tillage system	Cover crop	Soil temperature	Soil moisture	Soil WFSP
		°C	$m^3 m^{-3}$	%
CT	ncc	28.9	0.15	44.9
	oat	28.4	0.16	45.6
	oat+vetch	28.9	0.16	45.1
	vetch	28.2	0.17	45.0
MT	ncc	29.0	0.19	44.8
	oat	27.8	0.22	45.9
	oat+vetch	27.7	0.21	45.4
	vetch	27.9	0.21	45.0
NT	ncc	29.1	0.20	47.1
	oat	27.0	0.20	47.7
	oat+vetch	27.3	0.21	47.0
	vetch	27.5	0.20	47.6

Table S4. Relationship between CO_2 emission and soil temperature and moisture.

Tillage system	Cover crop	Period (weeks)	Soil moisture		Soil temperature	
			Regression equation	R^2	Regression equation	R^2
CT	ncc	1st	y = -0.0076x + 0.3601	0.48*	y = -0.3106x + 38.083	0.41*
		2nd	y = 0.0099x - 0.0994	0.15*	-	ns
		3rd–6th	-	ns	-	ns
		7th–18th	-	ns	-	ns
	oat	1st	-	ns	-	ns
		2nd	y = 0.0058x - 0.0839	0.81**	-	ns
		3rd–6th	y = 0.0043x - 0.0338	0.20*	-	ns
		7th–18th	-	ns	-	ns
	oat+vetch	1st	-	ns	-	ns
		2nd	y = 0.0018x + 0.0791	0.25*	y = 0.2251x + 16.29	0.35*
		3rd–6th	-	ns	-	ns
		7th–18th	y = -0.0031x + 0.3294	0.28*	y = 0.0821x + 20.854	0.16*
	vetch	1st	-	ns	-	ns
		2nd	y = 0.0017x + 0.0959	0.23*	y = 0.1475x + 18.617	0.24*
		3rd–6th	y = 0.0061x - 0.1236	0.66**	y = -0.324x + 48.229	0.16*
		7th–18th	-	ns	-	ns
MT	ncc	1st	y = 0.0147x - 0.0919	0.81**	y = -0.299x + 35.504	0.51*
		2nd	-	ns	y = 0.905x + 11.4	0.70***
		3rd–6th	y = -0.029x + 0.7385	0.95**	y = 1.1873x + 9.0283	0.60**
		7th–18th	y = -0.0059x + 0.3944	0.30*	y = 0.2199x + 18.241	0.34**
	oat	1st	-	ns	-	ns
		2nd	y = 0.0022x + 0.1639	0.49**	y = 0.1673x + 17.973	0.38**
		3rd–6th	y = 0.0171x - 0.3121	0.38*	y = -1.486x + 74.388	0.58*
		7th–18th	y = -0.0066x + 0.4372	0.31*	-	ns
	oat+vetch	1st	-	ns	-	ns
		2nd	y = 0.0014x + 0.1834	0.40*	y = 0.048x + 23.494	0.23**
		3rd–6th	y = 0.0119x - 0.2451	0.58**	y = -0.871x + 61.528	0.87***
		7th–18th	-	ns	y = 0.1293x + 19.948	0.20*
	vetch	1st	-	ns	-	ns

		2nd	y = 0.0025x + 0.055	0.79**	-	ns
		3rd–6th	y = 0.0065x - 0.0928	0.51**	y = -0.1879x + 41.21	0.22*
		7th–18th	y = -0.003x + 0.3578	0.22*	y = 0.0827x + 21.798	0.13*
NT	ncc	1st	y = 0.0069x + 0.0882	0.36**	-	ns
		2nd	y = 0.0069x + 0.0924	0.34*	y = 0.2693x + 22.498	0.16*
		3rd–6th	y = 0.0063x + 0.0391	0.24*	y = -0.560x + 42.693	0.21*
		7th–18th	-	ns	-	ns
	oat	1st	y = 0.0036x + 0.1304	0.87***	-	ns
		2nd	-	ns	-	ns
		3rd–6th	-	ns	y = -1.837x + 60.359	0.82***
		7th–18th	-	ns	-	ns
	oat+vetch	1st	y = 0.0017x + 0.2113	0.26*	y = -0.053x + 28.737	0.49**
		2nd	y = 0.0027x + 0.1292	0.50*	-	ns
		3rd–6th	y = 0.009x - 0.0127	0.33*	y = -0.484x + 38.521	0.55**
		7th–18th	-	ns	y = -0.200x + 34.569	0.30*
	vetch	1st	y = 0.0011x + 0.2347	0.63***	y = -0.029x + 27.763	0.15*
		2nd	y = 0.0017x + 0.1572	0.21*	-	ns
		3rd–6th	y = 0.0106x - 0.0635	0.51**	y = -0.412x + 38.571	0.54**
		7th–18th	-	ns	-	ns

Tillage system: conventional tillage (CT), minimum tillage (MT) and no-tillage (NT). Cover crops: no cover crop (ncc), oat, oat+vetch and vetch. Levels of significance: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ns = non-significant.