Conservation agriculture increases soil organic carbon stocks but not soil CO$_2$ efflux in two 8-year-old experiments in Zimbabwe

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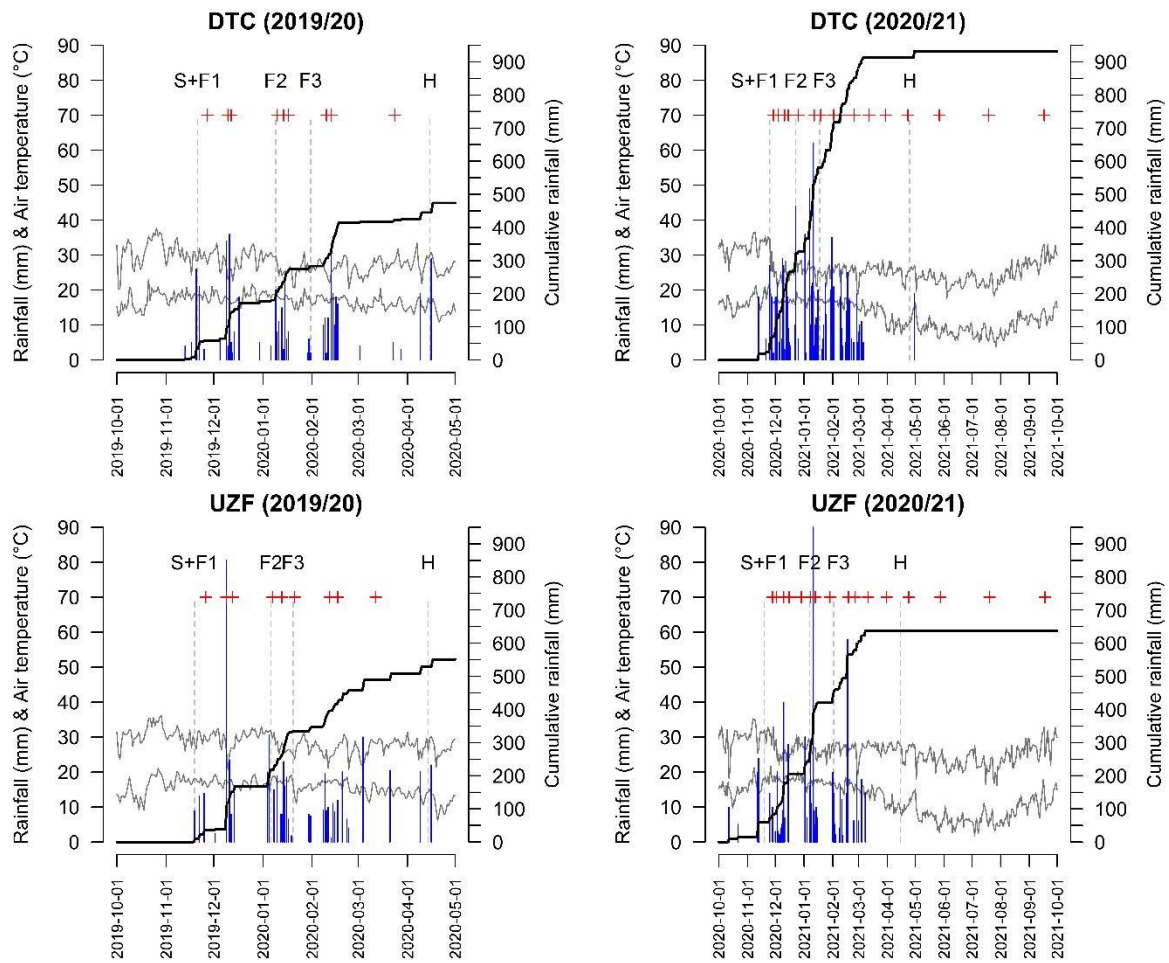
Figure S1. Daily and cumulative seasonal rainfall, maximum and minimum air temperature during the 2019/20 and 20/21 seasons at the Domboshava Training Centre (DTC) and University of Zimbabwe farm (UZF) experimental sites. S+F1: sowing + basal fertilizer application, F2: first nitrogen topdressing, F3: second nitrogen topdressing, H: maize harvesting. The red crosses indicate gas sampling dates. The upper and lower grey lines represent the maximum and minimum daily air temperature, respectively.
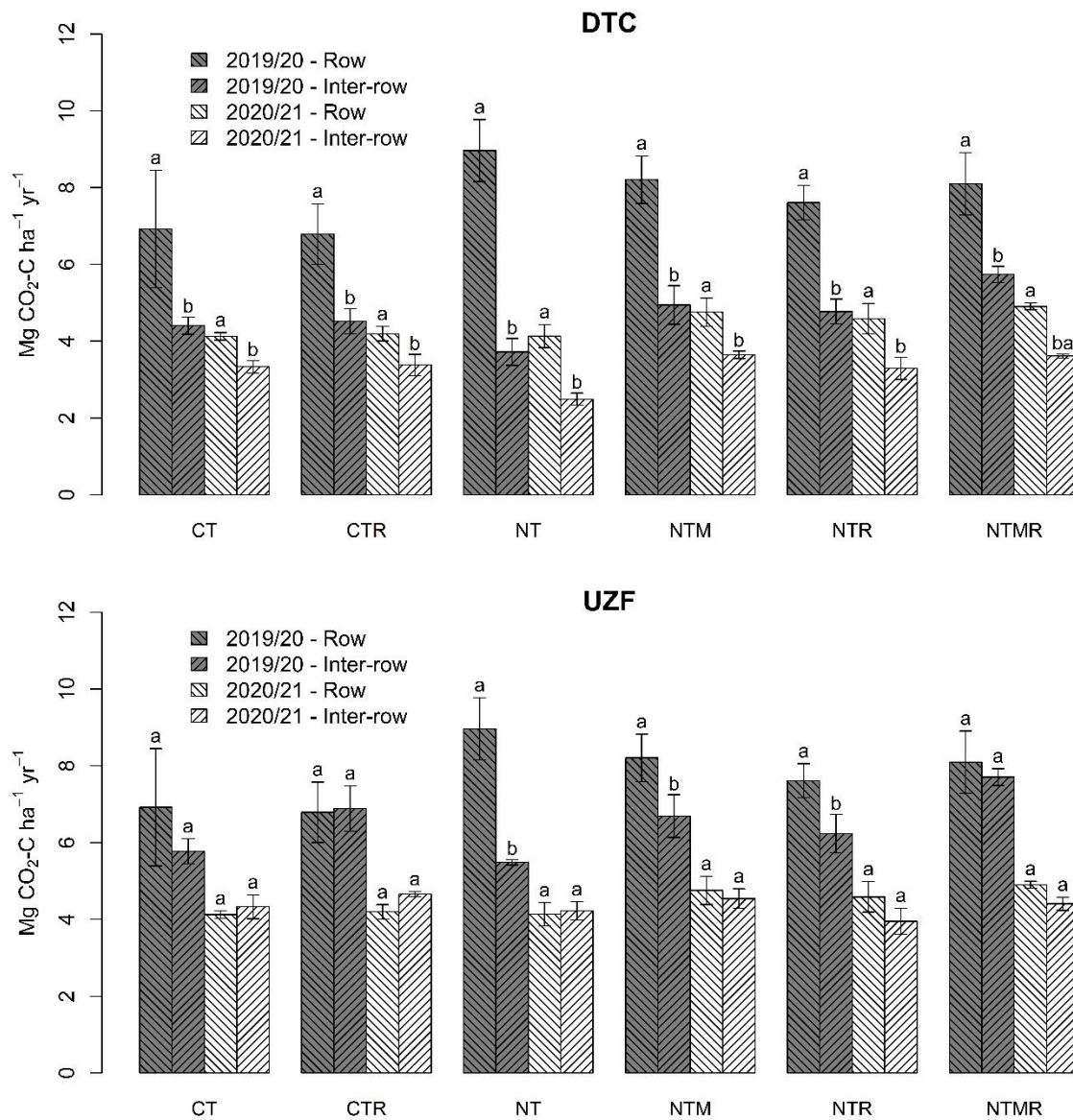
Figure S2. Row and inter-row cumulative CO_2-C emissions for the different treatments in the 2019/20 cropping season, the 2020/21 cropping season, and the whole year (2020/21) at Domboshava Training Centre (DTC) and University of Zimbabwe Farm (UZF). Bars represent standard errors (N = 4). CT: conventional tillage, CTR: conventional tillage with rotation, NT: no-tillage, NTM: no-tillage with mulch, NTR: no-tillage with rotation, NTMR: no-tillage with mulch and rotation.

Table S1: Subsoil bulk density (g cm^{-3}) from pits outside the experimental plots at Domboshava Training Centre (DTC) and the University of Zimbabwe (UZF). Associated errors are standard errors (N = 4).

Depth (cm)	Site	
	DTC	UZF
30-40	1.49 ($\pm$ 0.01)	1.47 ($\pm$ 0.01)
40-50	1.47 ($\pm$ 0.01)	1.49 ($\pm$ 0.00)
50-75	1.49 ($\pm$ 0.01)	1.48 ($\pm$ 0.01)
75-100	1.51 ($\pm$ 0.01)	1.48 ($\pm$ 0.01)

Table S2: Soil organic carbon concentration (mg C g^{-1}) for different treatments and depths at Domboshava Training Centre (DTC) and the University of Zimbabwe (UZF). Means in the same column followed by different superscript letters are significantly different and associated errors are standard errors (N = 4). CT = conventional tillage, CTR = conventional tillage with rotation, NT = no tillage, NTM = no tillage with mulch, NTR = no tillage with rotation, NTMR = no tillage with mulch and rotation, LSD = least significance difference, ns = not significant, Sig = significance.

Site	Treatment	Depth (cm)								
		0-5	5-10	10-15	15-20	20-30	30-40	40-50	50-75	75-100
DTC	CT	6.0 ± 0.56^d	5.0 ± 0.53^b	4.5 ± 0.37^a	4.1 ± 0.33^a	4.1 ± 0.37^a	3.8 ± 0.06^a	3.2 ± 0.14^a	2.6 ± 0.10^a	2.5 ± 0.17^a
	CTR	6.7 ± 0.27^{bcd}	5.4 ± 0.20^{ab}	4.6 ± 0.30^a	4.3 ± 0.30^a	4.2 ± 0.23^a	4.1 ± 0.21^a	3.3 ± 0.07^a	3.2 ± 0.08^a	2.7 ± 0.19^a
	NT	6.1 ± 0.54^{cd}	4.9 ± 0.29^b	4.2 ± 0.33^a	3.9 ± 0.31^a	3.8 ± 0.30^a	3.5 ± 0.25^a	2.9 ± 0.40^a	2.6 ± 0.32^a	2.4 ± 0.25^a
	NTM	8.8 ± 0.91^a	5.9 ± 0.31^a	4.9 ± 0.50^a	4.4 ± 0.24^a	4.0 ± 0.18^a	3.6 ± 0.22^a	3.0 ± 0.21^a	3.0 ± 0.36^a	2.5 ± 0.17^a
	NTR	8.0 ± 0.78^{abc}	5.9 ± 0.41^a	5.1 ± 0.33^a	4.5 ± 0.33^a	4.2 ± 0.24^a	4.1 ± 0.33^a	3.2 ± 0.17^a	2.9 ± 0.23^a	2.6 ± 0.29^a
	NTMR	8.1 ± 0.53^{ab}	5.6 ± 0.26^{ab}	4.7 ± 0.26^a	4.1 ± 0.24^a	4.4 ± 0.35^a	3.5 ± 0.29^a	3.2 ± 0.27^a	3.1 ± 0.39^a	2.6 ± 0.25^a
	LSD	1.28	0.59	0.70	0.68	0.65	0.56	0.59	0.68	0.60
	Sig	p = 0.001	p = 0.005	ns	ns	ns	ns	ns	ns	ns
UZF	CT	18.0 ± 0.32^c	17.4 ± 0.50^a	16.4 ± 0.24^a	14.9 ± 0.74^a	11.7 ± 0.44^a	10.3 ± 0.41^a	7.8 ± 0.58^a	8.5 ± 1.20^a	6.7 ± 0.70^a
	CTR	17.5 ± 0.30^c	16.7 ± 0.27^a	16.1 ± 0.26^a	15.1 ± 0.34^a	13.3 ± 0.24^a	11.9 ± 1.06^a	8.3 ± 0.38^a	9.1 ± 1.06^a	8.5 ± 1.00^a
	NT	18.6 ± 0.45^{bc}	17.6 ± 0.41^a	16.9 ± 0.49^a	15.3 ± 0.28^a	12.4 ± 0.32^a	9.5 ± 0.49^a	7.2 ± 0.14^a	8.0 ± 1.10^a	7.2 ± 1.21^a
	NTM	21.2 ± 0.8^a	18.4 ± 0.83^a	16.7 ± 0.72^a	15.9 ± 0.81^a	13.5 ± 0.91^a	11.4 ± 1.23^a	8.6 ± 0.90^a	9.2 ± 1.92^a	7.5 ± 0.62^a
	NTR	19.3 ± 0.37^{abc}	17.0 ± 0.28^a	15.6 ± 0.18^a	14.9 ± 0.17^a	11.4 ± 0.93^a	11.6 ± 0.34^a	8.8 ± 0.64^a	9.0 ± 1.90^a	8.1 ± 1.77^a
	NTMR	20.5 ± 0.70^{ab}	17.0 ± 0.52^a	15.3 ± 0.73^a	15.2 ± 0.23	12.0 ± 1.24^a	11.3 ± 0.55^a	8.7 ± 0.36^a	10.1 ± 2.38^a	9.0 ± 2.03^a
	LSD	1.42	1.17	1.33	1.45	2.39	2.18	1.75	3.33	2.81
	Sig	p < 0.001	ns	ns	ns	ns	ns	ns	ns	ns

Table S3: SOC stocks per soil layer at the Domboshava Training Centre (DTC) and University of Zimbabwe Farm (UZF) after 8 years of different tillage, residue and crop management systems. Means in the same row followed by different superscript letters are significantly different and associated errors are standard errors (N = 4). CT: conventional tillage, CTR: conventional tillage with rotation, NT: no-tillage, NTM: no-tillage with mulch, NTR: no-tillage with rotation, NTMR: no-tillage with mulch and rotation.

Site	ESM (Mg C ha⁻¹)	Approximate soil depth (cm)	SOC stocks (Mg C ha⁻¹)						LSD	Significance
			CT	CTR	NT	NTM	NTR	NTMR		
	650	0-5	3.9 ± 0.73^c	4.4 ± 0.18^{ab}	3.8 ± 0.35^c	5.9 ± 0.60^a	5.3 ± 0.51^b	5.4 ± 0.34^b	0.94	$p < 0.001$
	690	5-10	3.5 ± 0.73^b	3.9 ± 0.15^a	3.3 ± 0.20^b	4.0 ± 0.21^a	4.1 ± 0.28^a	4.0 ± 0.18^a	0.45	$p < 0.05$
	720	10-15	3.3 ± 0.53	3.4 ± 0.22	3.1 ± 0.23	3.6 ± 0.36	3.7 ± 0.23	3.5 ± 0.18	0.62	ns
	705	15-20	2.9 ± 0.47	3.0 ± 0.21	2.8 ± 0.22	3.2 ± 0.18	3.1 ± 0.23	2.9 ± 0.17	0.56	ns
DTC	1400	20-30	5.8 ± 1.04	5.7 ± 0.32	5.5 ± 0.42	5.6 ± 0.25	5.8 ± 0.33	6.2 ± 0.49	1.08	ns
	1430	30-40	5.5 ± 0.16	6.1 ± 0.24	5.3 ± 0.33	5.2 ± 0.30	6.0 ± 0.46	4.9 ± 0.40	0.93	ns
	1450	40-50	4.7 ± 0.37	4.6 ± 0.11	4.4 ± 0.56	4.5 ± 0.31	4.8 ± 0.26	4.8 ± 0.36	0.84	ns
	3510	50-75	8.9 ± 0.67	11.4 ± 0.26	9.2 ± 1.12	7.6 ± 2.35	10.0 ± 0.79	10.9 ± 1.34	1.83	ns
	3215	75-100	8.0 ± 1.08	8.9 ± 0.56	7.6 ± 0.81	8.0 ± 0.57	8.4 ± 0.93	8.1 ± 0.81	2.09	ns
	460	0-5	8.2 ± 0.15^{cd}	8.0 ± 0.14^c	8.6 ± 0.21^{cd}	9.6 ± 0.37^a	8.8 ± 0.17^{bc}	9.2 ± 0.32^{ab}	0.67	$p < 0.001$
	410	5-10	7.2 ± 0.17	6.9 ± 0.11	7.3 ± 0.15	7.7 ± 0.32	7.1 ± 0.12	7.1 ± 0.22	0.58	ns
	460	10-15	7.5 ± 0.16	7.3 ± 0.16	7.5 ± 0.28	7.8 ± 0.38	7.3 ± 0.06	7.3 ± 0.37	0.73	ns
	510	15-20	7.9 ± 0.25	7.8 ± 0.11	7.9 ± 0.09	8.2 ± 0.41	7.7 ± 0.14	7.4 ± 0.20	0.62	ns
UZF	930	20-30	11.6 ± 0.63	12.9 ± 0.26	12.8 ± 0.36	13.1 ± 0.78	11.0 ± 0.89	12.3 ± 0.90	1.98	ns
	1260	30-40	12.8 ± 0.49	15.4 ± 0.96	13.1 ± 0.30	14.5 ± 1.35	14.8 ± 0.45	14.2 ± 0.88	2.51	ns
	1270	40-50	11.1 ± 0.82	12.2 ± 0.36	10.4 ± 0.14	12.1 ± 1.25	12.1 ± 0.59	12.3 ± 0.37	2.22	ns
	2890	50-75	23.0 ± 3.13	25.6 ± 2.70	22.4 ± 2.57	$16.8 \pm (5.22$	24.9 ± 5.34	28.7 ± 5.99	12.91	ns
	2860	75-100	18.5 ± 2.24	23.2 ± 2.83	19.9 ± 3.41	20.1 ± 1.98	22.4 ± 5.01	26.5 ± 5.99	9.36	ns

Table S4: Seasonal organic carbon inputs (Mg C ha^{-1}) to soil for different treatments at Domboshava Training Centre (DTC) and the University of Zimbabwe (UZF). Means in the same column followed by different superscript letters are significantly different and associated errors are standard errors (N = 4). CT = conventional tillage, CTR = conventional tillage with rotation, NT = no tillage, NTM = no tillage with mulch, NTR = no tillage with rotation, NTMR = no tillage with mulch and rotation, LSD = least significance difference.

Site	Treatment	Seasons							
		2013/14*	2014/15	2015/16*	2016/17	2017/18*	2018/19	2019/20*	2020/21
DTC	CT	1.42 ± 0.15^b	1.01 ± 0.17^b	1.41 ± 0.05^b	1.22 ± 0.16^b	0.67 ± 0.09^b	0.67 ± 0.19^b	0.51 ± 0.09^c	0.51 ± 0.11^b
	CRT	0.42 ± 0.02^c	1.17 ± 0.09^b	0.23 ± 0.02^c	1.27 ± 0.12^b	0.54 ± 0.15^b	0.74 ± 0.22^b	1.07 ± 0.09^b	0.50 ± 0.14^b
	NT	1.18 ± 0.10^b	1.23 ± 0.23^b	1.22 ± 0.16^b	1.35 ± 0.19^b	0.69 ± 0.06^b	0.61 ± 0.09^b	0.47 ± 0.03^c	0.49 ± 0.05^b
	NTM	2.22 ± 0.07^a	2.25 ± 0.09^a	2.29 ± 0.12^a	2.27 ± 0.18^a	1.81 ± 0.07^a	1.79 ± 0.13^a	1.79 ± 0.10^a	1.57 ± 0.08^a
	NTR	0.51 ± 0.08^c	1.28 ± 0.02^b	0.22 ± 0.04^c	1.50 ± 0.12^b	0.52 ± 0.11^b	0.71 ± 0.13^b	1.25 ± 0.24^b	0.53 ± 0.10^b
	NTMR	0.62 ± 0.02^c	2.23 ± 0.16^a	0.36 ± 0.07^c	2.02 ± 0.09^a	0.45 ± 0.12^b	2.04 ± 0.14^a	1.76 ± 0.14^a	1.45 ± 0.01^a
	LSD	0.27	0.38	0.24	0.46	0.33	0.51	0.38	0.27
	Significance	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001
UZF	CT	0.77 ± 0.09^b	0.94 ± 0.11^b	1.25 ± 0.13^b	1.18 ± 0.05^e	0.99 ± 0.11^b	0.64 ± 0.05^c	0.40 ± 0.07^{bc}	1.02 ± 0.06^{cd}
	CRT	0.64 ± 0.07^b	1.06 ± 0.13^b	1.77 ± 0.31^{ab}	1.57 ± 0.06^{cd}	0.73 ± 0.15^{bc}	0.80 ± 0.03^b	0.32 ± 0.05^{cd}	1.20 ± 0.01^c
	NT	0.74 ± 0.07^b	1.08 ± 0.09^b	1.36 ± 0.05^b	1.36 ± 0.13^{ed}	0.78 ± 0.02^b	0.71 ± 0.05^c	0.50 ± 0.08^b	0.84 ± 0.02^d
	NTM	1.65 ± 0.04^a	2.10 ± 0.19^a	2.57 ± 0.08^a	2.10 ± 0.11^b	2.02 ± 0.01^a	1.98 ± 0.04^a	1.70 ± 0.05^a	2.05 ± 0.08^b
	NTR	0.66 ± 0.13^b	0.97 ± 0.13^b	2.17 ± 0.70^{ab}	1.74 ± 0.03^c	0.60 ± 0.09^b	0.78 ± 0.04^b	0.22 ± 0.02^d	1.07 ± 0.11^c
	NTMR	0.70 ± 0.05^b	2.01 ± 0.15^a	1.91 ± 0.41^{ab}	2.71 ± 0.07^a	0.93 ± 0.11^a	2.02 ± 0.04^a	0.31 ± 0.07^{cd}	2.28 ± 0.07^a
	LSD	0.46	0.37	1.16	0.26	0.31	0.14	0.12	0.20
	Significance	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001	p < 0.001

*Season when cowpea in rotation treatments was grown after maize was grown in the previous season.