Current economic obstacles to biochar use in agriculture and climate change mitigation

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Table S1. Yield effect and revenue of biochar soil application in field experiments with agricultural crops.

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N fertilizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Significance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/Mg BC)
1	Maize	C		S	0		0.72				
	Maize	BC2		S	0	2.0	1.1	1.53	*	0.38	11.24
	Maize	BC4		S	0	4.0	1.7	2.36	*	0.98	14.50
	Maize	MF30		S	30		0.87				
	Maize	MF30+BC2		S	30	2.0	1.2	1.38	*	0.33	9.76
	Maize	MF30+BC4		S	30	4.0	2.26	2.60	*	1.39	20.56
	Maize	MF60		S	60		0.99				
	Maize	MF60+BC2		S	60	2.0	1.43	1.44	*	0.44	13.02
	Maize	MF60+BC4		S	60	4.0	2.44	2.46	*	1.45	21.45
	Maize	MF90		S	90		1.05				
	Maize	MF90+BC2		S	90	2.0	1.68	1.60	*	0.63	18.64
	Maize	MF90+BC4		S	90	4.0	2.85	2.71	*	1.80	26.63
2	Maize	MF		S	150		7.14				
	Maize	MF+BC	BC10	S	150	10.0	9.21	1.29	*	2.07	12.25
	Maize	MF+Co		S	150		7.82				
	Maize	MF+BC+Co	BC2.5	S	150	2.5	8.57	1.10	n.s.	0.75	17.75
3	Maize	C		S	0		2.04				
	Maize	BC		S	0	30.0	2.39	1.17	*	0.35	0.68
	Maize	FYM		S	0		2.40				
	Maize	FYM+BC		S	0	30.0	3.19	1.33	*	0.79	1.56
	Maize	NPK		S	150		3.97				
	Maize	NPK+BC		S	150	30.0	4.19	1.06	n.s.	0.22	0.43
4	Rice	C	HK1_Apo	S	0		3.00				
	Rice	BC	HK1_Apo; BC4	S	0	4.0	2.30	0.77	*	-0.70	-57.75
	Rice	BC	HK1_Apo; BC8	S	0	8.0	2.70	0.90	n.s.	-0.30	-12.38
	Rice	BC	HK1_Apo; BC16	S	0	16.0	2.20	0.73	*	-0.80	-16.50
	Rice	MF	HK1_Apo	S	50		2.80				

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N fertilizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Significance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/Mg BC)
4 cont'd	Rice	MF+BC	HK1_Apo; BC4	S	50	4.0	3.20	1.14	n.s.	0.40	33.00
	Rice	MF+BC	HK1_Apo; BC8	S	50	8.0	3.30	1.18	n.s.	0.50	20.63
	Rice	MF+BC	HK1_Apo; BC16	S	50	16.0	2.70	0.96	n.s.	-0.10	-2.06
	Rice	C	HK1_Vieng	S	0		0.70				
	Rice	BC	HK1_Vieng; BC4	S	0	4.0	0.50	0.71	n.s.	-0.20	-16.50
	Rice	BC	HK1_Vieng; BC8	S	0	8.0	0.80	1.14	n.s.	0.10	4.13
	Rice	BC	HK1_Vieng; BC16	S	0	16.0	0.70	1.00	n.s.	0.00	0.00
	Rice	MF	HK1_Vieng	S	50		0.70				
	Rice	MF+BC	HK1_Vieng; BC4	S	50	4.0	1.50	2.14	*	0.80	66.00
	Rice	MF+BC	HK1_Vieng; BC8	S	50	8.0	1.00	1.43	n.s.	0.30	12.38
	Rice	MF+BC	HK1_Vieng; BC16	S	50	16.0	0.80	1.14	n.s.	0.10	2.06
	Rice	C	LO1_Apo	S	0		5.70				
	Rice	BC	LO1_Apo; BC4	S	0	4.0	5.10	0.89	n.s.	-0.60	-49.50
	Rice	BC	LO1_Apo; BC8	S	0	8.0	5.60	0.98	n.s.	-0.10	-4.13
	Rice	BC	LO1_Apo; BC16	S	0	16.0	5.90	1.04	n.s.	0.20	4.13
	Rice	MF	LO1_Apo	S	50		5.40				
	Rice	MF+BC	LO1_Apo; BC4	S	50	4.0	4.80	0.89	n.s.	-0.60	-49.50
	Rice	MF+BC	LO1_Apo; BC8	S	50	8.0	5.60	1.04	n.s.	0.20	8.25
	Rice	MF+BC	LO1_Apo; BC16	S	50	16.0	5.30	0.98	n.s.	-0.10	-2.06
	Rice	C	LO1_Vieng	S	0		3.80				
	Rice	BC	LO1_Vieng; BC4	S	0	4.0	3.60	0.95	n.s.	-0.20	-16.50
	Rice	BC	LO1_Vieng; BC8	S	0	8.0	4.00	1.05	n.s.	0.20	8.25
	Rice	BC	LO1_Vieng; BC16	S	0	16.0	3.70	0.97	n.s.	-0.10	-2.06
	Rice	MF	LO1_Vieng	S	50		3.00				
	Rice	MF+BC	LO1_Vieng; BC4	S	50	4.0	3.40	1.13	n.s.	0.40	33.00
	Rice	MF+BC	LO1_Vieng; BC8	S	50	8.0	3.70	1.23	n.s.	0.70	28.88
	Rice	MF+BC	LO1_Vieng; BC16	S	50	16.0	3.80	1.27	n.s.	0.80	16.50
	Rice	C	HK2_Apo	S	0		4.80				
	Rice	BC	HK2_Apo; BC8	S	0	8.0	4.30	0.90	n.s.	-0.50	-20.63

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/ Multiple (year) ^b	N ferti- lizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Signifi- cance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/ Mg BC)
4 cont'd	Rice	C	LO2_Apo	S	0		4.20				
	Rice	BC	LO2_Apo; BC8	S	0	8.0	4.70	1.12	*	0.50	20.63
	Rice	C	HK3_Apo	S	0		1.80				
	Rice	BC	HK3_Apo; BC8	S	0	8.0	2.20	1.22	*	0.40	16.50
	Rice	C	LO3_Apo	S	0		2.40				
	Rice	BC	LO3_Apo; BC8	S	0	8.0	2.70	1.13	n.s.	0.30	12.38
	Rice	C	SO-Apo	S	0		1.90				
	Rice	BC	SO-Apo; BC8	S	0	8.0	1.70	0.89	n.s.	-0.20	-8.25
	Rice	C	SN_Apo	S	0		3.20				
	Rice	BC	SN_Apo; BC8	S	0	8.0	3.50	1.09	n.s.	0.30	12.38
	Rice	C	LS_Apo	S	0		2.20				
	Rice	BC	LS_Apo; BC8	S	0	8.0	1.80	0.82	n.s.	-0.40	-16.50
5	Durum wheat	MF		S	114		2.8				
	Durum wheat	MF+BC	BC10	S	114	10	3.1	1.11	n.s.	0.30	2.84
	Maize	MF		S	413		9.7				
	Maize	MF+BC	BC10(CR)	S	413	10	12.1	1.25	*	2.40	14.20
	Maize	MF+BC	BC10(C+)	S	413	10	10.3	1.06	n.s.	0.60	3.55
6	Banana	MF		S	400		33.19				
	Banana	MF+BC		S	400	10.0	27.06	0.82	n.s.	-6.13	
	Banana	Compost		S	400		28.96				
	Banana	COMBI		S	400	10.0	25.43	0.88	n.s.	-3.53	
7 (f)	Wheat	C	Walkaway	S	0		1.76				
	Wheat	BC	Walkaway	S	0	0.1	1.60	0.91	n.s.	-0.16	-216.54
	Wheat	BC	Walkaway	S	0	0.3	1.87	1.06	n.s.	0.11	41.68
	Wheat	BC	Walkaway	S	0	0.5	1.84	1.05	n.s.	0.08	15.16
	Wheat	BC	Walkaway	S	0	1.0	1.85	1.05	n.s.	0.09	8.53
	Wheat	BC	Walkaway	S	0	2.0	2.14	1.22	*	0.38	18.00
	Wheat	BC	Walkaway	S	0	3.3	2.02	1.15	*	0.26	7.40
	Wheat	MF	Walkaway; MF50	S	50		1.84				

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N fertilizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Significance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/Mg BC)
7 cont'd	Wheat	BC+MF	Walkaway; MF50	S	50	0.1	1.71	0.93	n.s.	-0.13	-175.94
	Wheat	BC+MF	Walkaway; MF50	S	50	0.3	2.04	1.11	n.s.	0.20	75.79
	Wheat	BC+MF	Walkaway; MF50	S	50	0.5	2.10	1.14	*	0.26	49.26
	Wheat	BC+MF	Walkaway; MF50	S	50	1.0	2.16	1.17	*	0.32	30.32
	Wheat	BC+MF	Walkaway; MF50	S	50	2.0	2.27	1.23	*	0.43	20.37
	Wheat	BC+MF	Walkaway; MF50	S	50	3.3	1.95	1.06	n.s.	0.11	3.13
	Wheat	MF	Walkaway; MF100	S	0		2.14				
	Wheat	BC+MF	Walkaway; MF100	S	100	0.1	1.92	0.90	n.s.	-0.22	-297.74
	Wheat	BC+MF	Walkaway; MF100	S	100	0.3	1.99	0.93	n.s.	-0.15	-56.84
	Wheat	BC+MF	Walkaway; MF100	S	100	0.5	2.20	1.03	n.s.	0.06	11.37
	Wheat	BC+MF	Walkaway; MF100	S	100	1.0	2.18	1.02	n.s.	0.04	3.79
	Wheat	BC+MF	Walkaway; MF100	S	100	2.0	2.25	1.05	n.s.	0.11	5.21
	Wheat	BC+MF	Walkaway; MF100	S	100	3.3	2.02	0.94	n.s.	-0.12	-3.41
	Wheat	C	Moora	S	0		0.37				
	Wheat	BC	Moora	S	0	1.0	0.33	0.90	n.s.	-0.04	-3.32
	Wheat	MF	Moora; soluble P7	S	0		0.57				
	Wheat	MF+BC	Moora; soluble P7	S	0	1.0	0.80	1.40	*	0.23	21.51
	Wheat	MF	Moora; soluble P20	S	0		0.76				
	Wheat	MF+BC	Moora; soluble P20	S	0	1.0	0.87	1.15	*	0.11	10.61
	Wheat	MF	Moora; rock P7	S	0		0.38				
	Wheat	MF+BC	Moora; rock P7	S	0	1.0	0.37	0.99	n.s.	0.00	-0.38
	Wheat	MF	Moora; P-	S	0		0.38				
	Wheat	MF+BC	Moora; P-	S	0	1.0	0.43	1.16	n.s.	0.06	5.59
	Wheat	MF+Mic	Moora; P+; Mic	S	0		0.44				
	Wheat	MF+BC+Mic	Moora; P+; Mic	S	0	1.0	0.39	0.87	n.s.	-0.06	-5.31
	Wheat	MF	Moora	S	0		0.72				
	Wheat	BC+MF	Moora	S	0	1.0	0.74	1.02	n.s.	0.02	1.71
	Wheat	MF	Shea-Oak Log, DAP	S	0		2.72				
	Wheat	MF+BC	Shea-Oak Log; DAP	S	0	0.8	2.59	0.95	n.s.	-0.13	-16.42

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7 cont'd	Wheat	MF	Templers; DAP	S	0		3.33				
	Wheat	MF+BC	Templers; DAP	S	0	0.8	3.33	1.00	n.s.	0.00	0.00
8 (g)	Maize	C	2008	Y1	yes		8.56				
	Maize	BC45	2008	Y1	yes	45.0	4.49	0.52	*	-4.07	-5.35
	Maize	C	2009	Y2	yes		12.93				
	Maize	BC45	2009	Y2	yes	0	6.59	0.51	*	-6.34	-8.34
	Maize	C	2010	Y3	yes		1.13				
	Maize	BC45	2010	Y3	yes	0	1.34	1.19	n.s.	0.21	0.28
9 (h)	Maize	MF	Kaomo (2011)	Y1	77		0.8				
	Maize	MF+BC0.8(maize)	Kaomo (2011)	Y1	77	6.0	1.0	1.25	n.s.	0.20	1.97
	Maize	MF+BC4(maize)	Kaomo (2011)	Y1	77	30.0	4.2	5.25	*	3.40	6.71
	Maize	MF+BC0.8(wood)	Kaomo (2011)	Y1	77	6.0	1.2	1.50	n.s.	0.40	3.94
	Maize	MF+BC4(wood)	Kaomo (2011)	Y1	77	30.0	3.6	4.50	*	2.80	5.52
	Maize	MF	Kaomo (2012)	Y2	77		0.96				
	Maize	MF+BC0.8(maize)	Kaomo (2012)	Y2	77	0	1.32	1.38	n.s.	0.36	3.55
	Maize	MF+BC4(maize)	Kaomo (2012)	Y2	77	0	3.49	3.64	*	2.53	4.99
	Maize	MF+BC0.8(wood)	Kaomo (2012)	Y2	77	0	1.13	1.18	n.s.	0.17	1.68
	Maize	MF+BC4(wood)	Kaomo (2012)	Y2	77	0	2.43	2.53	*	1.47	2.90
	Maize	MF	UNZA (2011)	S	154		2.6				
	Maize	MF+BC5(maize)	UNZA (2011)	S	154	30.0	3.7	1.42	n.s.	1.10	2.17
	Maize	MF+BC1(wood)	UNZA (2011)	S	154	6.0	2.8	1.08	n.s.	0.20	1.97
	Maize	MF+BC5(wood)	UNZA (2011)	S	154	30.0	3.4	1.31	n.s.	0.80	1.58
	Maize	MF	Mkushi (2011)	Y1	77		4.8				
	Maize	MF+BC0.8(maize)	Mkushi (2011)	Y1	77	6.0	4.2	0.88	n.s.	-0.60	-5.92
	Maize	MF+BC4(maize)	Mkushi (2011)	Y1	77	30.0	3.5	0.73	n.s.	-1.30	-2.56
	Maize	MF+BC0.8(wood)	Mkushi (2011)	Y1	77	6.0	4.5	0.94	n.s.	-0.30	-2.96
	Maize	MF+BC4(wood)	Mkushi (2011)	Y1	77	30.0	5.6	1.17	n.s.	0.80	1.58
	Maize	MF	Mkushi (2012)	Y2	77		5.84				
	Maize	MF+BC0.8(maize)	Mkushi (2012)	Y2	77	0	6.32	1.08	n.s.	0.48	4.73

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9 cont'd	Maize	MF+BC4(maize)	Mkushi (2012)	Y2	77	0	4.80	0.82	n.s.	-1.04	-2.05
	Maize	MF+BC0.8(wood)	Mkushi (2012)	Y2	77	0	5.84	1.00	n.s.	0.00	0.00
	Maize	MF+BC4(wood)	Mkushi (2012)	Y2	77	0	6.4	1.10	n.s.	0.56	1.10
	Maize	MF	Lusaka (2011)	S	154		9.1				
	Maize	MF+BC0.8(maize)	Lusaka (2011)	S	154	6.0	9.0	0.99	n.s.	-0.10	-0.99
	Maize	MF+BC4(maize)	Lusaka (2011)	S	154	30.0	8.2	0.90	n.s.	-0.90	-1.78
	Maize	MF+BC0.8(wood)	Lusaka (2011)	S	154	6.0	6.8	0.75	n.s.	-2.30	-22.68
	Maize	MF+BC4(wood)	Lusaka (2011)	S	154	30.0	6.9	0.76	n.s.	-2.20	-4.34
	Maize	MF	Shim (2011)	S	154		8.6				
	Maize	MF+BC0.8(maize)	Shim (2011)	S	154	6.0	11.0	1.28	n.s.	2.40	23.67
	Maize	MF+BC4(maize)	Shim (2011)	S	154	30.0	6.7	0.78	n.s.	-1.90	-3.75
	Maize	MF+BC0.8(wood)	Shim (2011)	S	154	6.0	8.1	0.94	n.s.	-0.50	-4.93
	Maize	MF+BC4(wood)	Shim (2011)	S	154	30.0	8.1	0.94	n.s.	-0.50	-0.99
10	Wheat	C	Year 1	Y1	120		2.45				
	Wheat	MF+BC	Year 1	Y1	120	10	2.00	0.82	n.s.	-0.45	-4.26
	Wheat	MF+BC	Year 1	Y1	120	20	2.49	1.02	n.s.	0.04	0.19
	Wheat	MF+BC	Year 1	Y1	120	40	2.53	1.03	n.s.	0.08	0.19
	Wheat	C	Year 2	Y2	120		5.31				
	Wheat	MF+BC	Year 2	Y2	120	0	5.62	1.06	n.s.	0.31	2.94
	Wheat	MF+BC	Year 2	Y2	120	0	5.66	1.07	n.s.	0.35	1.66
	Wheat	MF+BC	Year 2	Y2	120	0	5.91	1.11	n.s.	0.60	1.42
11	Barley	MF	Inceptosol	S	70		27.1				
	Barley	MF+BC5	Inceptosol	S	70	5.0	23.8	0.88	n.s.	-3.30	-55.79
	Barley	MF+BC10	Inceptosol	S	70	10.0	25.3	0.93	n.s.	-1.80	-15.22
	Barley	MF+BC20	Inceptosol	S	70	20.0	28.5	1.05	*	1.40	5.92
	Barley	MF	Ultisol	S	60		2.35				
	Barley	MF+BC5	Ultisol	S	60	5.0	2.59	1.10	n.s.	0.24	4.06
	Barley	MF+BC10	Ultisol	S	60	10.0	2.75	1.17	n.s.	0.40	3.38
	Barley	MF+BC20	Ultisol	S	60	20.0	2.87	1.22	*	0.52	2.20

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12	Wheat	C	2010	Y1	0		2.48				
	Wheat	BC0.04	2010	Y1	0	0.035	2.33	0.94	n.s.	-0.15	-407.34
	Wheat	BC0.18	2010	Y1	0	0.175	2.36	0.95	n.s.	-0.13	-68.43
	Wheat	BC5	2010	Y1	0	5.0	2.38	0.96		-0.10	-1.96
	Wheat	MF(DAP low)	2010	Y1	6		2.63				
	Wheat	MF(low)+BC	2010	Y1	6	0.035	2.60	0.99	n.s.	-0.02	-65.17
	Wheat	MF(low)+BC	2010	Y1	6	0.175	2.55	0.97	n.s.	-0.08	-43.45
	Wheat	MF(low)+BC	2010	Y1	6	5.0	2.63	1.00		0.01	0.11
	Wheat	MF(DAP high)	2010	Y1	13		2.68				
	Wheat	MF(high)+BC	2010	Y1	13	0.035	2.72	1.01	n.s.	0.04	103.19
	Wheat	MF(high)+BC	2010	Y1	13	0.175	2.73	1.02	n.s.	0.04	23.90
	Wheat	MF(high)+BC	2010	Y1	13	5.0	2.87	1.07		0.18	3.48
	Wheat	C	2011	Y2	0		2.07				
	Wheat	BC	2011	Y2	0	0	1.70	0.82	n.s.	-0.37	-1001.50
	Wheat	BC	2011	Y2	0	0	1.72	0.83	n.s.	-0.35	-189.47
	Wheat	BC	2011	Y2	0	0	1.85	0.89		-0.22	-4.17
	Wheat	MF(DAP low)	2011	Y2	6		2.01				
	Wheat	MF(low)+BC	2011	Y2	6	0	2.05	1.02	n.s.	0.04	108.27
	Wheat	MF(low)+BC	2011	Y2	6	0	1.83	0.91	n.s.	-0.18	-95.64
	Wheat	MF(low)+BC	2011	Y2	6	0	2.04	1.01		0.03	0.51
	Wheat	MF(DAP high)	2011	Y2	13		2.05				
	Wheat	MF(high)+BC	2011	Y2	13	0	2.22	1.08	n.s.	0.17	451.13
	Wheat	MF(high)+BC	2011	Y2	13	0	2.03	0.99	n.s.	-0.02	-10.83
	Wheat	MF(high)+BC	2011	Y2	13	0	2.25	1.10	n.s.	0.20	3.79
13	Sugar beet	C		S	0		40.3				
	Sugar beet	BC(HSP)		S	0	10	10.2	0.25	*	-30.06	-435.87
	Sugar beet	BC(HBD)		S	0	10	26.9	0.67	*	-13.32	-193.14
	Sugar beet	C+MF50		S	50		45.8				
	Sugar beet	BC(HSP)+MF50		S	50	10	25.0	0.55	*	-20.76	-301.02

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N fertilizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Significance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/Mg BC)
13 cont'd	Sugar beet	BC(HBD)+MF50		S	50	10	31.0	0.68	*	-14.82	-214.89
	Sugar beet	C+MF100		S	100		49.8				
	Sugar beet	BC(HSP)+MF100		S	100	10	32.5	0.65	*	-17.34	-251.43
	Sugar beet	BC(HBD)+MF100		S	100	10	32.2	0.65	*	-17.58	-254.91
14	Maize	C	Peanut hull (2006)	Y1	26		4.70				
	Maize	BC	Peanut hull (2006)	Y1	26	11.0	3.05	0.65	n.s.	-1.65	-8.88
	Maize	BC	Peanut hull (2006)	Y1	26	22.0	6.07	1.29	n.s.	1.37	3.68
	Maize	MF	Peanut hull (2006)	Y1	192		13.00				
	Maize	MB+BC	Peanut hull (2006)	Y1	192	11.0	13.42	1.03	n.s.	0.42	2.26
	Maize	MB+BC	Peanut hull (2006)	Y1	192	22.0	11.68	0.90	n.s.	-1.32	-3.55
	Maize	C	Peanut hull (2007)	Y2	22		0.92				
	Maize	BC	Peanut hull (2007)	Y2	22	0	0.92	1.00	n.s.	0.00	0.00
	Maize	BC	Peanut hull (2007)	Y2	22	0	1.36	1.48	n.s.	0.44	1.18
	Maize	MF	Peanut hull (2007)	Y2	246		8.61				
	Maize	MB+BC	Peanut hull (2007)	Y2	246	0	8.55	0.99	n.s.	-0.06	-0.32
	Maize	MB+BC	Peanut hull (2007)	Y2	246	0	8.09	0.94	n.s.	-0.52	-1.40
	Maize	C	Pine chip (2006)	Y1	26		4.45				
	Maize	BC	Pine chip (2006)	Y1	26	11.0	3.41	0.77	n.s.	-1.04	-5.59
	Maize	BC	Pine chip (2006)	Y1	26	22.0	3.12	0.70	n.s.	-1.33	-3.58
	Maize	MF	Pine chip (2006)	Y1	192		15.13				
	Maize	MB+BC	Pine chip (2006)	Y1	192	11.0	14.52	0.96	n.s.	-0.61	-3.28
	Maize	MB+BC	Pine chip (2006)	Y1	192	22.0	13.65	0.90	n.s.	-1.48	-3.98
	Maize	C	Pine chip (2007)	Y2	22		0.52				
	Maize	BC	Pine chip (2007)	Y2	22	0	0.74	1.42	n.s.	0.22	1.18
	Maize	BC	Pine chip (2007)	Y2	22	0	0.81	1.56	n.s.	0.29	0.78
	Maize	MF	Pine chip (2007)	Y2	246		8.70				
	Maize	MB+BC	Pine chip (2007)	Y2	246	0	10.69	1.23	n.s.	1.99	10.70
	Maize	MB+BC	Pine chip (2007)	Y2	246	0	8.87	1.02	n.s.	0.17	0.46

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/ Multiple (year) ^b	N ferti- lizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Signifi- cance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/ Mg BC)
15	Silage maize	MF		S	200		5.43				
	Silage maize	MF+BC		S	200	1.0	7.03	1.30	n.s.	1.60	
	Silage maize	MF+BC		S	200	40.0	5.50	1.01	n.s.	0.07	
	Silage maize	MF+Dig		S	200		5.56				
	Silage maize	MF+Dig+BC		S	200	1,0	6.67	1.20	n.s.	1.10	
	Silage maize	MF+Dig+BC		S	200	40,0	7.89	1.42	*	2.32	
	Silage maize	MF+Dig(ferm)		S	200		8.90				
	Silage maize	MF+Dig(f)+BC		S	200	40,0	4.55	0.51	*	-4.35	
	Silage maize	MF+Co		S	200		5.58				
	Silage maize	MF+Co+BC		S	200	10.0	7.03	1.26		1.45	
16	Maize	C	T1	S	0		2.54				
	Maize	BC	T2	S	0	5.0	4.60	1.81	*	2.06	24.38
	Maize	BC	T3	S	0	7.5	4.85	1.91	*	2.31	18.22
	Maize	MF75%	T4	S	101		4.85				
	Maize	MF75%+BC	T8	S	101	5.0	7.15	1.47	*	2.30	27.22
	Maize	MF75%+BC	T10	S	101	7.5	7.45	1.54	*	2.60	20.51
	Maize	MF100%	T5	S	135		5.08				
	Maize	MF100%+BC	T9	S	135	5.0	7.28	1.43	*	2.20	26.04
	Maize	MF100%+BC	T11	S	135	7.5	7.65	1.51	*	2.57	20.28
	Maize	MF75%+biofert	T6	S	101		5.00				
	Maize	MF75%+biofert+BC	T12	S	101	5.0	7.70	1.54	*	2.70	31.95
	Maize	MF75%+biofert+BC	T14	S	101	7.5	7.60	1.52	*	2.60	20.51
	Maize	MF100%+biofert	T7	S	135		5.13				
	Maize	MF100%+biofert+BC	T13	S	135	5.0	8.10	1.58	*	2.97	35.15
	Maize	MF100%+biofert+BC	T15	S	135	7.5	7.73	1.51	*	2.60	20.51
17 (i)	Maize	C (90% N)	Year 1	Y1	109		4.74				
	Maize	BC	Year 1	Y1	109	3	4.11	0.87	n.s.	-0.63	-12.43
	Maize	BC	Year 1	Y1	109	12	4.19	0.88	n.s.	-0.55	-2.71
	Maize	BC	Year 1	Y1	109	30	4.02	0.85	n.s.	-0.72	-1.42

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N ferti-lizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Signifi-cance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/Mg BC)
17 cont'd	Maize	C (90% N)	Year 2	Y2	109		9.26				
	Maize	BC	Year 2	Y2	109	0	7.8	0.84	n.s.	-1.46	-28.80
	Maize	BC	Year 2	Y2	109	0	8.14	0.88	n.s.	-1.12	-5.52
	Maize	BC	Year 2	Y2	109	0	7.77	0.84	n.s.	-1.49	-2.94
	Maize	C(90% N)	Year 3	Y3	109		8.5				
	Maize	BC	Year 3	Y3	109	0	8.51	1.00	n.s.	0.01	0.20
	Maize	BC	Year 3	Y3	109	0	7.93	0.93	n.s.	-0.57	-2.81
	Maize	BC	Year 3	Y3	109	0	6.59	0.78	n.s.	-1.91	-3.77
	Maize	C(90% N)	Year 4	Y4	109		8.69				
	Maize	BC	Year 4	Y4	109	0	8.6	0.99	n.s.	-0.09	-1.78
	Maize	BC	Year 4	Y4	109	0	8.62	0.99	n.s.	-0.07	-0.35
	Maize	BC	Year 4	Y4	109	0	7.81	0.90	n.s.	-0.88	-1.74
	Maize	C	Year 1 (50% N)	Y1	66		5.66				
	Maize	BC	Year 1: BC (50% N)	Y1	66	12	3.38	0.60	n.s.	-2.28	-11.24
	Maize	C	Year 1 (70% N)	Y1	87		4.27				
	Maize	BC	Year 1: BC (70% N)	Y1	87	12	3.38	0.79	n.s.	-0.89	-4.39
	Maize	C	Year 1 (90% N)	Y1	109		4.74				
	Maize	BC	Year 1: BC (90% N)	Y1	109	12	4.2	0.89	n.s.	-0.54	-2.66
	Maize	C	Year 1 (100% N)	Y1	120		4.5				
	Maize	BC	Year 1: BC (100% N)	Y1	120	12	4.66	1.04	n.s.	0.16	0.79
	Maize	C	Year 2 (50% N)	Y2	66		6.99				
	Maize	BC	Year 2: BC (50% N)	Y2	66	0	6.83	0.98	n.s.	-0.16	-0.79
	Maize	C	Year 2 (70% N)	Y2	87		7.37				
	Maize	BC	Year 2: BC (70% N)	Y2	87	0	8.28	1.12	n.s.	0.91	4.49
	Maize	C	Year 2 (90% N)	Y2	109		9.26				
	Maize	BC	Year 2: BC (90% N)	Y2	109	0	8.14	0.88	n.s.	-1.12	-5.52
	Maize	C	Year 2 (100% N)	Y2	120		10.41				
	Maize	BC	Year 2: BC (100% N)	Y2	120	0	11.38	1.09	n.s.	0.97	4.78
	Maize	C	Year 3 (50% N)	Y3	66		6.5				

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N ferti-lizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Signifi-cance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/Mg BC)
17 cont'd	Maize	BC	Year 3: BC (50% N)	Y3	66	0	6.64	1.02	n.s.	0.14	0.69
	Maize	C	Year 3 (70% N)	Y3	87		8.01				
	Maize	BC	Year 3: BC (70% N)	Y3	87	0	7.75	0.97	n.s.	-0.26	-1.28
	Maize	C	Year 3 (90% N)	Y3	109		8.5				
	Maize	BC	Year 3: BC (90% N)	Y3	109	0	7.89	0.93	n.s.	-0.61	-3.01
	Maize	C	Year 3 (100% N)	Y3	120		8.59				
	Maize	BC	Year 3: BC (100% N)	Y3	120	0	10.91	1.27	n.s.	2.32	11.44
	Maize	C	Year 4 (50% N)	Y4	66		7.29				
	Maize	BC	Year 4: BC (50% N)	Y4	66	0	7.41	1.02	n.s.	0.12	0.59
	Maize	C	Year 4 (70% N)	Y4	87		8.42				
	Maize	BC	Year 4: BC (70% N)	Y4	87	0	8.23	0.98	n.s.	-0.19	-0.94
	Maize	C	Year 4 (90% N)	Y4	109		8.69				
	Maize	BC	Year 4: BC (90% N)	Y4	109	0	8.62	0.99	n.s.	-0.07	-0.35
	Maize	C	Year 4 (100% N)	Y4	120		8.94				
	Maize	BC	Year 4: BC (100% N)	Y4	120	0	8.94	1.00	n.s.	0.00	0.00
18	Rice	C	IRRI, year 1	Y1	0		3.84				
	Rice	BC	IRRI, year 1	Y1	0	41.3	3.81	0.99	n.s	-0.03	-0.24
	Rice	MF	IRRI, year 1	Y1	60		5.22				
	Rice	MF+BC	IRRI, year 1	Y1	60	41.3	4.72	0.90	n.s	-0.50	-4.00
	Rice	C	IRRI, year 2	Y2	0		3.02				
	Rice	BC	IRRI, year 2	Y2	0	0	2.89	0.96	n.s	-0.13	-1.04
	Rice	MF	IRRI, year 2	Y2	60		4.94				
	Rice	MF+BC	IRRI, year 2	Y2	60	0	4.32	0.87	*	-0.62	-4.95
	Rice	C	IRRI, year 3	Y3	0		3.2				
	Rice	BC	IRRI, year 3	Y3	0	0	3.16	0.99	n.s	-0.04	-0.32
	Rice	MF	IRRI, year 3	Y3	60		4.06				
	Rice	MF+BC	IRRI, year 3	Y3	60	0	4.07	1.00	n.s	0.01	0.08
	Rice	C	IRRI, year 4	Y4	0		3.23				
	Rice	BC	IRRI, year 4	Y4	0	0	3.11	0.96	n.s	-0.12	-0.96

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N fertilizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Significance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/Mg BC)
18 cont'd	Rice	MF	IRRI, year 4	Y4	60		4.24				
	Rice	MF+BC	IRRI, year 4	Y4	60	0	3.9	0.92	n.s	-0.34	-2.72
	Rice	C	Siniloan, year 1	Y1	0		3.01				
	Rice	BC	Siniloan, year 1	Y1	0	41.3	3.52	1.17	n.s	0.51	4.08
	Rice	MF	Siniloan, year 1	Y1	60		2.56				
	Rice	MF+BC	Siniloan, year 1	Y1	60	41.3	2.83	1.11	n.s	0.27	2.16
	Rice	C	Siniloan, year 2	Y2	0		3.01				
	Rice	BC	Siniloan, year 2	Y2	0	0	3.3	1.10	n.s	0.29	2.32
	Rice	MF	Siniloan, year 2	Y2	60		3.19				
	Rice	MF+BC	Siniloan, year 2	Y2	60	0	3.29	1.03	n.s	0.10	0.80
	Rice	C	Siniloan, year 3	Y3	0		3.09				
	Rice	BC	Siniloan, year 3	Y3	0	0	3.13	1.01	n.s	0.04	0.32
	Rice	MF	Siniloan, year 3	Y3	60		3.33				
	Rice	MF+BC	Siniloan, year 3	Y3	60	0	3.54	1.06	n.s	0.21	1.68
	Rice	C	Ubon, year 1	Y1	0		2.63				
	Rice	BC	Ubon, year 1	Y1	0	41.3	2.73	1.04	n.s	0.10	0.80
	Rice	MF	Ubon, year 1	Y1	40		3.31				
	Rice	MF+BC	Ubon, year 1	Y1	40	41.3	3.71	1.12	n.s	0.40	3.20
	Rice	C	Ubon, year 2	Y2	0		2.18				
	Rice	BC	Ubon, year 2	Y2	0	0	2.76	1.27	*	0.58	4.63
	Rice	MF	Ubon, year 2	Y2	40		2.63				
	Rice	MF+BC	Ubon, year 2	Y2	40	0	3.33	1.27	*	0.70	5.59
	Rice	C	Ubon, year 3	Y3	0		1.97				
	Rice	BC	Ubon, year 3	Y3	0	0	1.75	0.89	n.s	-0.22	-1.76
	Rice	MF	Ubon, year 3	Y3	40		2.00				
	Rice	MF+BC	Ubon, year 3	Y3	40	0	2.64	1.32	*	0.64	5.11
	Rice	C	Ubon, year 4	Y4	0		1.51				
	Rice	BC	Ubon, year 4	Y4	0	0	1.76	1.17	n.s	0.25	2.00
	Rice	MF	Ubon, year 4	Y4	40		2.01				

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N fertilizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Significance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/Mg BC)
cont'd	Rice	MF+BC	Ubon, year 4	Y4	40	0	2.72	1.35	n.s.	0.71	5.67
19 (k)	Wheat	(+P)		Y1	92		5.16				
	Wheat	BC(WS) +P		Y1	92	5.0	5.23	1.01	n.s.	0.06	1.18
	Wheat	BC(CM) +P		Y1	92	5.0	5.34	1.03	n.s.	0.17	3.28
	Wheat	no P		Y1	92		4.51				
	Wheat	BC(WS) no P		Y1	92	5.0	5.06	1.12	*	0.54	10.27
	Wheat	BC(CM) no P		Y1	92	5.0	5.11	1.13	*	0.59	11.23
	Sorghum	(+P)	Catch crop	Y1-2	0		1.19				
	Sorghum	BC(WS) +P	Catch crop	Y1-2	0	0	1.53	1.29	*	0.34	
	Sorghum	BC(CM) +P	Catch crop	Y1-2	0	0	1.44	1.21	n.s.	0.25	
	Sorghum	no P	Catch crop	Y1-2	0		1.13				
	Sorghum	BC(WS) no P	Catch crop	Y1-2	0	0	1.54	1.37	*	0.41	
	Sorghum	BC(CM) no P	Catch crop	Y1-2	0	0	1.29	1.14	n.s.	0.16	
	Lupin	(+P)		Y2	4		2.76				
	Lupin	BC(WS) +P		Y2	4	0	2.70	0.98	n.s.	-0.07	-2.42
	Lupin	BC(CM) +P		Y2	4	0	3.27	1.18	n.s.	0.51	18.23
	Lupin	no P		Y2	4		2.60				
	Lupin	BC(WS) no P		Y2	4	0	2.31	0.89	n.s.	-0.29	-10.49
	Lupin	BC(CM) no P		Y2	4	0	2.85	1.10	n.s.	0.25	8.93
	Sorghum	(+P)	Catch crop	Y2-3	0		3.69				
	Sorghum	BC(WS) +P	Catch crop	Y2-3	0	0	3.79	1.03	n.s.	0.11	
	Sorghum	BC(CM) +P	Catch crop	Y2-3	0	0	4.80	1.30	n.s.	1.11	
	Sorghum	no P	Catch crop	Y2-3	0		3.48				
	Sorghum	BC(WS) no P	Catch crop	Y2-3	0	0	3.95	1.13	n.s.	0.47	
	Sorghum	BC(CM) no P	Catch crop	Y2-3	0	0	4.17	1.20	n.s.	0.69	
	Wheat	(+P)		Y3	92		3.81				
	Wheat	BC(WS) +P		Y3	92	0	3.71	0.98	n.s.	-0.09	-1.78
	Wheat	BC(CM) +P		Y3	92	0	3.81	1.00	n.s.	0.00	-0.03
	Wheat	no P		Y3	92		3.52				

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N ferti-lizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Signifi-cance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/Mg BC)
19 cont'd	Wheat	BC(WS) no P		Y3	92	0	3.52	1.00	n.s.	0.00	0.02
	Wheat	BC(CM) no P		Y3	92	0	3.45	0.98	n.s.	-0.06	-1.23
20 (l) (m)	Barley	C	Year 1	Y1	n.d.		7.88				
	Barley	BC	Year 1	Y1	n.d.	10	8.43	1.07	n.s.	0.55	4.65
	Rapeseed	C	Year 2	Y2	n.d.		3.39				
	Rapeseed	BC	Year 2	Y2	n.d.	0	3.71	1.09	n.s.	0.32	16.74
	Wheat	C	Year 3	Y3	n.d.		8.81				
	Wheat	BC	Year 3	Y3	n.d.	0	9.28	1.05	*	0.47	4.45
	Rapeseed	C	Year 1	Y1	n.d.		3.36				
	Rapeseed	BC	Year 1	Y1	n.d.	10	4.12	1.23	n.s.	0.76	39.76
	Rapeseed	BC	Year 1	Y1	n.d.	20	3.72	1.11	n.s.	0.36	9.42
	Rapeseed	BC	Year 10	Y1	n.d.	40	3.52	1.05	n.s.	0.16	2.09
	Wheat	C	Year 2	Y2	n.d.		8.78				
	Wheat	BC	Year 2	Y2	n.d.	0	9.31	1.06	*	0.53	5.02
	Wheat	BC	Year 2	Y2	n.d.	0	8.88	1.01	n.s.	0.10	0.47
	Wheat	BC	Year 2	Y2	n.d.	0	8.51	0.97	*	-0.27	-0.64
	Sugar beet	MF	Year 1	S	125		8.86				
	Sugar beet	MF+BC	Year 1	S	125	10	8.64	0.98	n.s.	-0.22	-3.19
	Sugar beet	MF+BC	Year 1	S	125	20	10.35	1.17	n.s.	1.49	10.80
	Sugar beet	MF+BC	Year 1	S	125	40	8.8	0.99	n.s.	-0.06	-0.22
	Carrots	C	Year 1	S	75		16.55				
	Carrots	BC	Year 1	S	75	10	18.8	1.14	n.s.	2.25	
	Carrots	BC	Year 1	S	75	20	17.2	1.04	n.s.	0.65	
	Carrots	BC	Year 1	S	75	40	18.33	1.11	n.s.	1.78	
	Barley	C		S	n.d.		8.87				
	Barley	BC	BC10	S	n.d.	10	8.9	1.00	n.s.	0.03	0.25
	Barley	BC	BC20	S	n.d.	20	9.09	1.02	n.s.	0.22	0.93
	Barley	BC	BC40	S	n.d.	40	8.87	1.00	n.s.	0.00	0.00
	Spinach	C		S	n.d.		30.61				

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/ Multiple (year) ^b	N ferti- lizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Signifi- cance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/ Mg BC)
20 cont'd	Spinach	BC	BC6	S	n.d.	6	29.96	0.98	n.s.	-0.65	
	Spinach	BC	BC12	S	n.d.	12	29.23	0.95	n.s.	-1.38	
	Spinach	BC	BC24	S	n.d.	24	29.38	0.96	n.s.	-1.23	
	Spinach	BC	BC40	S	n.d.	40	29.34	0.96	n.s.	-1.27	
	Spinach	C		S	n.d.		31.74				
	Spinach	BC	BC12: deep banded	S	n.d.	12	26.51	0.87	*	-5.23	
	Spinach	BC	BC24: deep banded	S	n.d.	24	30.71	1.00	n.s.	-1.03	
	Spinach	BC	BC40: deep banded	S	n.d.	40	28.44	0.93	n.s.	-3.30	
	Spinach	BC	BC80: deep banded	S	n.d.	80	30.86	1.01	n.s.	-0.88	
	Wheat	C		S	n.d.		8.316				
	Wheat	BC	BC: 10	S	n.d.	10	8.696	1.05	n.s.	0.38	3.60
	Vicia faba	C		S	n.d.		5.31				
	Vicia faba	BC	BC: 10	S	n.d.	10	7.51	1.41	n.s.	2.20	
	Vicia faba	BC	BC: 30	S	n.d.	30	5.41	1.02	n.s.	0.10	
	Vicia faba	C		S	n.d.		5.38				
	Vicia faba	BC	BC: 10	S	n.d.	10	5.28	1.02	n.s.	-0.10	
	Vicia faba	BC	BC: 30	S	n.d.	30	4.65	1.00	n.s.	-0.73	
	Pisum sativum	C		S	n.d.		1.79				
	Pisum sativum	BC	BC: 10	S	n.d.	10	1.41	0.79	n.s.	-0.38	
	Pisum sativum	BC	BC: 30	S	n.d.	30	1.35	0.75	*	-0.44	
	Pisum sativum	C		S	n.d.		7.28				
	Pisum sativum	BC	BC: 10	S	n.d.	10	7.36	1.01	n.s.	0.08	
	Pisum sativum	BC	BC: 30	S	n.d.	30	8.76	1.20	n.s.	1.48	
	Barley	C		S	144		4.429				
	Barley	MF+BC	BC: 10	S	144	10	9.595	2.17	*	5.17	
	Barley	MF+BC	BC: 30	S	144	30	9.111	2.06	*	4.68	
21	Maize	MF	Maize+Manioc - Maize	Y1	180		3.06				
	Maize	MF+BC	Maize+Manioc - Maize	Y1	180	15.0	4.06	1.33	*	1.00	3.94
	Manioc	MF	Maize+Manioc - Manioc	Y1	180		16.44				

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21 cont'd	Manihoc	MF+BC	Maize+Manioc - Manioc	Y1	180	15.0	18.33	1.11	*	1.89	
	Maize	MF	Maize	Y1	180		4.09				
	Maize	MF+BC	Maize	Y1	180	15.0	4.17	1.02	n.s.	0.08	0.32
	Manioc	MF	Manioc	Y1	180		30.67				
	Manihoc	MF+BC	Manioc	Y1	180	15.0	32.66	1.06	n.s.	1.99	
	Maize	MF	Maize+Manioc - Maize	Y2	180		2.73				
	Maize	MF+BC	Maize+Manioc - Maize	Y2	180	0	4.13	1.51	*	1.40	5.52
	Manioc	MF	Maize+Manioc - Manioc	Y2	180		14.40				
	Manihoc	MF+BC	Maize+Manioc - Manioc	Y2	180	0	23.20	1.61	*	8.80	
	Maize	MF	Maize	Y2	180		3.62				
	Maize	MF+BC	Maize	Y2	180	0	3.99	1.10	*	0.37	1.46
	Manioc	MF	Manioc	Y2	180		22.35				
	Manihoc	MF+BC	Manioc	Y2	180	0	32.06	1.43	*	9.71	
	Maize	MF	Maize+Manioc - Maize	Y3	180		2.06				
	Maize	MF+BC	Maize+Manioc - Maize	Y3	180	0	3.89	1.89	*	1.83	7.22
	Manioc	MF	Maize	Y3	180		3.06				
	Manioc	MF+BC	Maize	Y3	180	0	4.06	1.33	*	1.00	3.94
22 (m)	Spring barley	MF		S	81		6.69				
	Spring barley	MF+BC20		S	81	20.0	6.47	0.97	n.s.	-0.22	-0.93
	Spring barley	MF+BC50		S	81	50.0	5.77	0.86	n.s.	-0.92	-1.56
	Potatoes	MF		S	250		72.0				
	Potatoes	MF+BC20		S	250	20.0	85.6	1.19	n.s.	13.60	123.08
	Potatoes	MF+BC50		S	250	50.0	74.0	1.03	n.s.	2.00	7.24
23	Silage maize	MF	Year 1; Maize	Y1	100	-	26.00				
	Silage maize	MF+BC	Year 1; Maisze	Y1	100	25.0	25.00	0.96	n.s.		
	Silage maize	MF+BC	Year 1; Maize	Y1	100	50.0	26.00	1.00	n.s.		
	Ryegrass	MF	Year 2, grass	Y2	100		4.30				
	Ryegrass	MF+BC	Year 2; grass	Y2	100	0	4.50	1.05	n.s.		
	Ryegrass	MF+BC	Year 2; grass	Y2	100	0	5.80	1.35	n.s.		

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/ Multiple (year) ^b	N ferti- lizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Signifi- cance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/ Mg BC)
22 cont'd	Ryegrass	C	Year 3; grass	Y3	0		3.80				
	Ryegrass	BC	Year 3; grass	Y3	0	0	6.50	1.71	*		
	Ryegrass	BC	Year 3; grass	Y3	0	0	6.80	1.79	*		
24	Barley	MF	Year 1	Y1	120		5.4				
	Barley	MF+BC	Year 1	Y1	120	24	5.2	0.96	n.s.	-0.20	-0.70
	Barley	MF+BC	Year 1	Y1	120	72	5.9	1.09	*	0.50	0.59
	Barley	BC	Year 1	Y1	0	72	4.7	0.87	*	-0.70	-0.82
	Sunflower	MF	Year 2	Y2	120		3.7				
	Sunflower	MF+BC	Year 2	Y2	120	0	4	1.08	*	0.30	5.70
	Sunflower	MF+BC	Year 2	Y2	120	0	3.5	0.95	n.s.	-0.20	-1.27
	Sunflower	BC	Year 2	Y2	0	0	3.4	0.92	n.s.	-0.30	-1.90
	Maize	C	Year 1	Y1	75		7.1				
	Maize	MF+BC	Year 1	Y1	75	24	8.1	1.14	n.s.	1.00	2.47
	Maize	MF+BC	Year 1	Y1	75	72	7.8	1.10	n.s.	0.70	0.58
	Maize	BC	Year 1	Y1	0	72	4	0.56	*	-3.10	-2.55
	Wheat	C	Year 2	Y2	120		5.3				
	Wheat	MF+BC	Year 2	Y2	120	0	5.1	0.96	n.s.	-0.20	-0.79
	Wheat	MF+BC	Year 2	Y2	120	0	5.5	1.04	n.s.	0.20	0.26
	Wheat	BC	Year 2	Y2	0	0	1.5	0.28	*	-3.80	-5.00
25	Maize	MF	Clayey soil	S	120		6.03				
	Maize	MF+BC	Sandy soil	S	120	6.0	6.21	1.03	n.s.	0.18	1.78
	Maize	MF	Clayey soil	S	120		8.53				
	Maize	MF+BC	Sandy soil	S	120	6.0	6.64	0.78	*	-1.89	-18.64
26	Silage maize	C	Year 1	Y1	200		18.1				
	Silage maize	BC	Year 1	Y1	200	22.4	19.45	1.07	n.s.	1.35	
	Silage maize	Mic	Year 1	Y1	0		18				
	Silage maize	BC+Mic	Year 1	Y1	0	22.4	18.6	1.03	n.s.	0.60	
	Silage maize	C	Year 2	Y2	224		23.3				
	Silage maize	BC	Year 2	Y2	224	0	16.1	0.69	*	-7.20	

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26 cont'd	Silage maize	Mic	Year 2	Y2	67		25.9				
	Silage maize	BC+Mic	Year 2	Y2	67	0	26.4	1.13	n.s.	0.50	
27	Rice	C	Site GH	S	0		8.38				
	Rice	BC20	Site GH	S	0	20.0	8.18	0.98	n.s.	-0.20	-3.30
	Rice	BC40	Site GH	S	0	40.0	8.29	0.99	n.s.	-0.09	-0.74
	Rice	MF	Site GH	S	240		9.04				
	Rice	MF+BC20	Site GH	S	240	20.0	9.00	1.00	n.s.	-0.04	-0.66
	Rice	MF+BC40	Site GH	S	240	40.0	9.10	1.01	n.s.	0.06	0.50
	Rice	C	Site CS	S	0		6.38				
	Rice	BC20	Site CS	S	0	20.0	6.36	1.00	n.s.	-0.02	-0.33
	Rice	BC40	Site CS	S	0	40.0	6.36	1.00	n.s.	-0.02	-0.17
	Rice	MF	Site CS	S	240		7.85				
	Rice	MF+BC20	Site CS	S	240	20.0	7.74	0.99	n.s.	-0.11	-1.82
	Rice	MF+BC40	Site CS	S	240	40.0	8.17	1.04	n.s.	0.32	2.64
	Rice	C	Site JX	S	0		6.67				
	Rice	BC20	Site JX	S	0	20.0	6.63	0.99	n.s.	-0.04	-0.66
	Rice	BC40	Site JX	S	0	40.0	6.80	1.02	n.s.	0.13	1.07
	Rice	MF	Site JX	S	300		7.92				
	Rice	MF+BC20	Site JX	S	300	20.0	8.33	1.05	*	0.41	6.77
	Rice	MF+BC40	Site JX	S	300	40.0	8.55	1.08	*	0.63	5.20
28 (n)	Maize	MF		Y1	300		6.65				
	Maize	MF+BC20		Y1	300	20.0	7.86	1.18	*	1.21	3.58
	Maize	MF+BC40		Y1	300	40.0	7.42	1.12	*	0.77	1.14
	Wheat	MF		Y2	300		7.62				
	Wheat	MF+BC20		Y2	300	0	7.45	0.98	n.s.	-0.17	-0.81
	Wheat	MF+BC40		Y2	300	0	7.87	1.03	n.s.	0.25	0.59
	Wheat	MF		Y4	300		7.81				
	Wheat	MF+BC20		Y4	300	0	7.83	1.00	n.s.	0.02	0.09
	Wheat	MF+BC40		Y4	300	0	8.07	1.03	n.s.	0.26	0.62

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28 cont'd	Maize	MF		Y5	300		8.31				
	Maize	MF+BC20		Y5	300	0	8.35	1.00	n.s.	0.04	0.12
	Maize	MF+BC40		Y5	300	0	9.11	1.10	n.s.	0.80	1.18
29	Rapeseed	MF		Y1	90		1.38				
	Rapeseed	MF+BC2.5		Y1	90	2.5	1.67	1.21	*	0.29	60.67
	Rapeseed	MF+BC5		Y1	90	5	1.68	1.22	*	0.30	31.38
	Rapeseed	MF+BC10		Y1	90	10	1.91	1.38	*	0.53	27.72
	Rapeseed	MF+BC20		Y1	90	20	1.85	1.34	*	0.47	12.29
	Rapeseed	MF+BC30		Y1	90	30	2.07	1.50	*	0.69	12.03
	Rapeseed	MF+BC40		Y1	90	40	2.19	1.59	*	0.81	10.59
	sweet potato	MF		Y2	90		2.07				
	sweet potato	MF+BC2.5		Y2	90	0	2.00	0.97	*	-0.07	
	sweet potato	MF+BC5		Y2	90	0	2.29	1.11	*	0.22	
	sweet potato	MF+BC10		Y2	90	0	3.53	1.71	*	1.46	
	sweet potato	MF+BC20		Y2	90	0	3.78	1.83	*	1.71	
	sweet potato	MF+BC30		Y2	90	0	4.15	2.00	*	2.08	
	sweet potato	MF+BC40		Y2	90	0	4.47	2.16	*	2.40	
30 (o)	Maize	MF	Year 1	Y1	165		4.94				
	Maize	MF+BC	Year 1	Y1	165	8.0	4.88	0.99	n.s.	-0.06	-0.44
	Maize	MF+BC	Year 1	Y1	165	20.0	4.82	0.98	n.s.	-0.12	-0.36
	Maize	MF	Year 2	Y2	170		5.00				
	Maize	MF+BC	Year 2	Y2	170	0	5.94	1.19	*	0.94	6.95
	Maize	MF+BC	Year 2	Y2	170	0	6.44	1.29	*	1.44	4.26
	Maize	MF	Year 3	Y3	156		5.76				
	Maize	MF+BC	Year 3	Y3	156	0	6.59	1.14	n.s.	0.83	6.14
	Maize	MF+BC	Year 3	Y3	156	0	7.50	1.30	*	1.74	5.15
	Maize	MF	Year 4	Y4	159		1.85				
	Maize	MF+BC	Year 4	Y4	159	0	3.12	1.69	*	1.27	9.39
	Maize	MF+BC	Year 4	Y4	159	0	4.41	2.38	*	2.56	7.57

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N fertilizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Significance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/Mg BC)
31	Maize	Co (C)	Forchheim (2011)	Y1	140		12.30				
	Maize	Co+HTC	Forchheim (2011)	Y1	140	20	11.12	0.90	n.s.	-1.19	-3.52
	Maize	Co+Pyro	Forchheim (2011)	Y1	140	20	12.04	0.98	n.s.	-0.27	-0.79
	Maize	Dig (C)	Forchheim (2011)	Y1	110		11.89				
	Maize	Dig+HTC	Forchheim (2011)	Y1	110	20	10.64	0.90	n.s.	-1.24	-3.67
	Maize	Dig+Pyro	Forchheim (2011)	Y1	110	20	11.82	0.99	n.s.	-0.06	-0.19
	Maize	MF (C)	Forchheim (2011)	Y1	160		11.52				
	Maize	MF+HTC	Forchheim (2011)	Y1	160	20	12.41	1.08	n.s.	0.88	2.61
	Maize	MF+Pyro	Forchheim (2011)	Y1	160	20	12.03	1.04	n.s.	0.50	1.49
	Wheat	Co (C)	Forchheim (2012)	Y2	150		8.38				
	Wheat	Co+HTC	Forchheim (2012)	Y2	150	0	8.18	0.98	n.s.	-0.20	-0.95
	Wheat	Co+Pyro	Forchheim (2012)	Y2	150	0	8.61	1.03	n.s.	0.23	1.08
	Wheat	Dig (C)	Forchheim (2012)	Y2	150		7.18				
	Wheat	Dig+HTC	Forchheim (2012)	Y2	150	0	8.07	1.12	n.s.	0.89	4.20
	Wheat	Dig+Pyro	Forchheim (2012)	Y2	150	0	7.99	1.11	n.s.	0.81	3.86
	Wheat	MF (C)	Forchheim (2012)	Y2	150		8.23				
	Wheat	MF+HTC	Forchheim (2012)	Y2	150	0	8.39	1.02	n.s.	0.16	0.75
	Wheat	MF+Pyro	Forchheim (2012)	Y2	150	0	7.68	0.93	n.s.	-0.56	-2.64
	Barley	Co (C)	Forchheim (2013)	Y3	105		6.34				
	Barley	Co+HTC	Forchheim (2013)	Y3	105	0	5.98	0.94	n.s.	-0.36	-1.51
	Barley	Co+Pyro	Forchheim (2013)	Y3	105	0	6.31	1.00	n.s.	-0.03	-0.12
	Barley	Dig (C)	Forchheim (2013)	Y3	105		5.94				
	Barley	Dig+HTC	Forchheim (2013)	Y3	105	0	5.84	0.98	n.s.	-0.10	-0.42
	Barley	Dig+Pyro	Forchheim (2013)	Y3	105	0	4.76	0.80	n.s.	-1.18	-4.97
	Barley	MF (C)	Forchheim (2013)	Y3	105		4.86				
	Barley	MF+HTC	Forchheim (2013)	Y3	105	0	5.45	1.12	n.s.	0.59	2.49
	Barley	MF+Pyro	Forchheim (2013)	Y3	105	0	5.11	1.05	n.s.	0.25	1.06
	Maize	Co (C)	March (2011)	Y1	140		17.42				
	Maize	Co+HTC	March (2011)	Y1	140	20	17.71	1.02	n.s.	0.29	0.86

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31 cont'd	Maize	Co+Pyro	March (2011)	Y1	140	20	19.14	1.10	n.s.	1.72	5.10
	Maize	Dig (C)	March (2011)	Y1	110		17.84				
	Maize	Dig+HTC	March (2011)	Y1	110	20	17.99	1.01	n.s.	0.16	0.46
	Maize	Dig+Pyro	March (2011)	Y1	110	20	17.39	0.97	n.s.	-0.45	-1.33
	Maize	MF (C)	March (2011)	Y1	160		17.32				
	Maize	MF+HTC	March (2011)	Y1	160	20	18.39	1.06	n.s.	1.07	3.15
	Maize	MF+Pyro	March (2011)	Y1	160	20	17.64	1.02	n.s.	0.32	0.94
	Maize	Co (C)	March (2012)	Y2	160		16.34				
	Maize	Co+HTC	March (2012)	Y2	160	0	16.69	1.02	n.s.	0.35	1.02
	Maize	Co+Pyro	March (2012)	Y2	160	0	18.30	1.12	n.s.	1.95	5.78
	Maize	Dig (C)	March (2012)	Y2	160		15.97				
	Maize	Dig+HTC	March (2012)	Y2	160	0	16.81	1.05	n.s.	0.84	2.49
	Maize	Dig+Pyro	March (2012)	Y2	160	0	16.07	1.01	n.s.	0.09	0.28
	Maize	MF (C)	March (2012)	Y2	160		16.74				
	Maize	MF+HTC	March (2012)	Y2	160	0	15.99	0.96	n.s.	-0.75	-2.21
	Maize	MF+Pyro	March (2012)	Y2	160	0	16.79	1.00	n.s.	0.06	0.16
	Maize	Co (C)	March (2013)	Y3	130		12.11				
	Maize	Co+HTC	March (2013)	Y3	130	0	11.27	0.93	n.s.	-0.84	-2.49
	Maize	Co+Pyro	March (2013)	Y3	130	0	10.76	0.89	n.s.	-1.35	-4.00
	Maize	Dig (C)	March (2013)	Y3	130		12.00				
	Maize	Dig+HTC	March (2013)	Y3	130	0	11.62	0.97	n.s.	-0.38	-1.13
	Maize	Dig+Pyro	March (2013)	Y3	130	0	12.06	1.00	n.s.	0.05	0.15
	Maize	MF (C)	March (2013)	Y3	130		12.58				
	Maize	MF+HTC	March (2013)	Y3	130	0	12.27	0.98	n.s.	-0.31	-0.92
	Maize	MF+Pyro	March (2013)	Y3	130	0	12.60	1.00	n.s.	0.02	0.05
32	Rice	C		S	0		0.02				
	Rice	BC		S	0	8.3	0.10	6.67	*	0.09	3.38
	Rice	MF+Ca		S	30		1.36				
	Rice	MF+BC+Ca		S	30	8.3	1.79	1.31	n.s.	0.43	17.02

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32 cont'd	Rice	Co		S	0		5.33				
	Rice	BC+Co		S	0	4.2	2.87	0.54	*	-2.45	-192.83
	Rice	BC+Co		S	0	8.3	3.72	0.70	n.s.	-1.61	-63.94
	Rice	Co+MF+Ca		S	30		7.26				
	Rice	MF+BC+Co+Ca		S	30	4.2	5.21	0.72	n.s.	-2.05	-161.32
	Rice	MF+BC+Co+Ca		S	30	8.3	4.18	0.58	n.s.	-3.08	-122.63
33	Spring barley	MF	2012	Y1	70		5.90				
	Spring barley	MF+BC20	2012	Y1	70	20.0	5.87	0.99	n.s.	-0.03	-0.13
	Rye	MF	2013	Y2	70		4.87				
	Rye	MF+BC20	2013	Y2	70	0	4.48	0.92	n.s.	-0.39	-6.44
34	Maize	MF	2011	Y1	377		6.92				
	Maize	MF+BC19	2011	Y1	377	19.2	7.66	1.11	n.s.	0.74	2.28
	Maize	MF+BC38	2011	Y1	377	38.3	8.11	1.17	n.s.	1.19	1.84
	Maize	MF+BC57	2011	Y1	377	57.5	10.30	1.49	*	3.38	3.48
	Maize	MF+BC77	2011	Y1	377	76.6	10.15	1.47	*	3.23	2.50
	Maize	MF+BC96	2011	Y1	377	95.8	10.68	1.54	*	3.76	2.32
	Maize	MF	2012	Y2	264		7.65				
	Maize	MF+BC19	2012	Y2	264	0	9.09	1.19	n.s.	1.44	4.44
	Maize	MF+BC38	2012	Y2	264	0	10.39	1.36	n.s.	2.74	4.23
	Maize	MF+BC57	2012	Y2	264	0	7.82	1.02	n.s.	0.17	0.17
	Maize	MF+BC77	2012	Y2	264	0	7.81	1.02	n.s.	0.16	0.12
	Maize	MF+BC96	2012	Y2	264	0	7.18	0.94	n.s.	-0.47	-0.29
35	Ryegrass	C		Y1	0		3.68				
	Ryegrass	BC	BC(manure)	Y1	0	10.0	4.58	1.25	n.s.	0.91	
	Ryegrass	BC	BC(slurry)	Y1	0	10.0	3.68	1.00	n.s.	0.01	
	Ryegrass	MF		Y1	368		7.44				
	Ryegrass	MF+BC	BC(manure)	Y1	368	10.0	8.59	1.15	n.s.	1.15	
	Ryegrass	MF+BC	BC(slurry)	Y1	368	10.0	7.34	0.99	n.s.	-0.11	
	Ryegrass	Ca		Y2	0		3.65				

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/ Multiple (year) ^b	N ferti- lizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Signifi- cance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/ Mg BC)
35 cont'd	Ryegrass	BC+Ca	BC(manure)	Y2	0	0	4.06	1.11	n.s.	0.42	
	Ryegrass	BC+Ca	BC(slurry)	Y2	0	0	3.54	0.87	n.s.	-0.11	
	Ryegrass	MF+Ca		Y2	368		6.79				
	Ryegrass	MF+BC+Ca	BC(manure)	Y2	368	0	8.50	1.25	n.s.	1.71	
	Ryegrass	MF+BC+Ca	BC(slurry)	Y2	368	0	7.49	1.10	n.s.	0.70	
36	Wheat	MF	MF55 soluble	S	15		1.79				
	Wheat	MF+BC	MF55 soluble	S	15	1.5	1.79	1.00	n.s.	-0.01	-0.32
	Wheat	MF	MF55 soluble	S	15		1.87				
	Wheat	MF+BC	MF55 soluble	S	15	6.0	1.81	0.97	n.s.	-0.06	-0.99
	Wheat	MF	MF30 soluble	S	13		1.88				
	Wheat	MF+BC	MF30 soluble	S	13	1.5	1.89	1.01	n.s.	0.01	0.63
	Wheat	MF	MF30 soluble	S	13		1.96				
	Wheat	MF+BC	MF30 soluble	S	13	6.0	2.31	1.18	*	0.34	5.43
	Wheat	MF	MF100 solid	S	16		1.35				
	Wheat	MF+BC	MF100 solid	S	16	1.5	2.03	1.51	*	0.68	43.07
	Wheat	MF	MF100 solid	S	16		1.41				
	Wheat	MF+BC	MF100 solid	S	16	6.0	2.01	1.43	*	0.60	9.51
	Wheat	MF	MF55 soluble	S	12		0.87				
	Wheat	MF+BC	MF55 soluble	S	12	1.5	0.93	1.07	*	0.06	3.60
	Wheat	MF	MF55 soluble	S	12		0.87				
	Wheat	MF+BC	MF55 soluble	S	12	6.0	0.94	1.09	*	0.08	1.20
37	Sorghum	MF	First harvest	Y1	60		0.28				
	Sorghum	MF+BC	First harvest	Y1	60	11.0	0.42	1.50	n.s.	0.14	0.81
	Sorghum	MF	Second harvest	Y2	55		0.14				
	Sorghum	MF+BC	Second harvest	Y2	55	0	0.28	2.00	n.s.	0.14	0.81
38	Lettuce	MF		S	113		7.4				
	Lettuce	MF+BC		S	113	5.0	7.3	0.99	n.s.	-0.10	
	Cover crop	MF	Winter cover crop	S	0		12.6				
	Cover crop	MF+BC	Winter cover crop	S	0	10.0	11.3	0.90	n.s.	-1.30	

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N ferti-lizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Signifi-cance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/ Mg BC)
38 cont'd	lettuce	MF		S	113		15.9				
	lettuce	MF+BC		S	113	10.0	9.3	0.58	*	-6.60	
39	Maize	MF	Year 1	Y1	135		5.27				
	Maize	MF+BC	Year 1; BC(coconut shell)	Y1	135	15.0	5.71	1.08	n.s.	0.44	1.74
	Maize	MF+BC	Year 1; BC(cattl dung)	Y1	135	15.0	5.81	1.10	*	0.54	2.13
		MF	Year 2	Y2	135		4.67				
	Maize	MF+BC	Year 2; BC(coconut shell)	Y2	135	0	5.65	1.21	*	0.98	3.87
	Maize	MF+BC	Year 2; BC(cattl dung)	Y2	135	0	5.87	1.26	*	1.20	4.73
40	Maize	C	2010	Y1	0		6.67				
	Wheat	B5	2010	Y1	0	5	6.33	0.95	n.s.	-0.34	-6.44
	Wheat	B10	2010	Y1	0	10	6.43	0.96	n.s.	-0.24	-2.27
	Wheat	C	2011	Y2	0		6.58				
	Wheat	B5	2011	Y2	0	0	6.57	1.00	n.s.	-0.01	-0.19
	Wheat	B10	2011	Y2	0	0	6.57	1.00	n.s.	-0.01	-0.09
	Wheat	C	2012	Y3	0		6.07				
	Wheat	B5	2012	Y3	0	0	5.62	0.93	n.s.	-0.45	-8.53
	Wheat	B10	2012	Y3	0	0	5.89	0.97	n.s.	-0.18	-1.71
	Rapeseed	C	2010	Y1	0		1.2				
	Rapeseed	B5	2010	Y1	0	5	1.01	0.84	n.s.	-0.19	-21.47
	Rapeseed	B10	2010	Y1	0	10	1.13	0.94	n.s.	-0.07	-3.96
	Rapeseed	C	2011	Y2	0		1.05				
	Rapeseed	B5	2011	Y2	0	0	1.02	0.97	n.s.	-0.03	-3.39
	Rapeseed	B10	2011	Y2	0	0	1.07	1.02	n.s.	0.02	1.13
	Rapeseed	C	2012	Y3	0		0.76				
	Rapeseed	B5	2012	Y3	0	0	0.67	0.88	n.s.	-0.09	-10.17
	Rapeseed	B10	2012	Y3	0	0	0.79	1.04	n.s.	0.03	1.70
	Vicia faba	C	2010	Y1	0		3.32				

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N ferti-lizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Signifi-cance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/Mg BC)
40 cont'd	Vicia faba	B5	2010	Y1	0	5	3.27	0.98	n.s.	-0.05	-2.61
	Vicia faba	B10	2010	Y1	0	10	3.28	0.99	n.s.	-0.04	-1.04
	Vicia faba	C	2011	Y2	0		3.77				
	Vicia faba	B5	2011	Y2	0	0	3.87	1.03	n.s.	0.1	5.22
	Vicia faba	B10	2011	Y2	0	0	3.83	1.02	n.s.	0.06	1.57
	Vicia faba	C	2012	Y3	0		4.77				
	Vicia faba	B5	2012	Y3	0	0	4.40	0.92	n.s.	-0.37	-19.31
	Vicia faba	B10	2012	Y3	0	0	4.66	0.98	n.s.	-0.11	-2.87
41	Spring wheat	C	2011	Y1	0		3.80				
	Spring wheat	B5	2011	Y1	0	5	3.50	0.92	n.s.	-0.30	-5.68
	Spring wheat	B10	2011	Y1	0	10	3.60	0.95	n.s.	-0.20	-1.89
	Spring wheat	B20	2011	Y1	0	20	3.40	0.89	n.s.	-0.40	-1.89
	Spring wheat	B30	2011	Y1	0	30	4.10	1.08	n.s.	0.30	0.95
	Spring wheat	C	2012	Y2	0		2.00				
	Spring wheat	B5	2012	Y2	0	0	1.90	0.95	n.s.	-0.10	-1.89
	Spring wheat	B10	2012	Y2	0	0	1.80	0.90	n.s.	-0.20	-1.89
	Spring wheat	B20	2012	Y2	0	0	1.60	0.80	n.s.	-0.40	-1.89
	Spring wheat	B30	2012	Y2	0	0	1.90	0.95	n.s.	-0.10	-0.32
42	Durum wheat	MF	Year 1	Y1	122		2.28				
	Durum wheat	MF+BC	Year 1	Y1	122	30.0	2.92	1.28	*	0.64	2.02
	Durum wheat	MF+BC	Year 1	Y1	122	60.0	2.93	1.29	*	0.65	1.03
	Durum wheat	MF	Year 2	Y2	122		2.18				
	Durum wheat	MF+BC	Year 2	Y2	122	0	2.90	1.33	n.s.	0.72	2.27
	Durum wheat	MF+BC	Year 2	Y2	122	0	2.71	1.24	n.s.	0.53	0.84
	Durum wheat	MF	2 nd trial (single year)	S	122		2.40				
	Durum wheat	MF+BC	2 nd trial (single year)	S	122	30.0	3.19	1.33	*	0.79	2.49
	Durum wheat	MF+BC	2 nd trial (single year)	S	122	60.0	3.34	1.39	*	0.94	1.48
43 (p)	Tomato	MF		S	110		88.33				
	Tomato	MF+BC	Slow pyrolysis	S	110	14.0	86.20	0.98	n.s.	-2.13	

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N fertilizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Significance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/Mg BC)
	Tomato	MF+BC	Fast pyrolysis	S	110	14.0	92.29	1.04	n.s.	3.96	
44 (q)	Maize	MF	Field A	S	75		7.55				
	Maize	MF+BC	Field A	S	75	10.0	14.71	1.95	*	7.16	
	Cowpea	MF	Field A	S	75		12.04				
	Cowpea	MF+BC	Field A	S	75	10.0	13.76	1.14	n.s.	1.72	
	Groundnut	MF	Field A	S	75		4.30				
	Groundnut	MF+BC	Field A	S	75	10.0	5.76	1.34	*	1.46	
	Maize	MF	Field B	S	75		10.45				
	Maize	MF+BC	Field B	S	75	10.0	10.06	0.96	n.s.	-0.39	
	Cowpea	MF	Field B	S	75		11.35				
	Cowpea	MF+BC	Field B	S	75	10.0	12.56	1.11	n.s.	1.21	
	Groundnut	MF	Field B	S	75		5.85				
	Groundnut	MF+BC	Field B	S	75	10.0	6.54	1.12	n.s.	0.69	
	Maize	MF	Field C	S	75		10.36				
	Maize	MF+BC	Field C	S	75	10.0	15.30	1.48	*	4.94	
	Maize	C	Field C	S	0		9.23				
	Maize	BC	Field C	S	0	10.0	11.50	1.25	*	2.27	
45 (r)	Maize	MF		S	yes		10.50				
	Maize	MF+BC	BC(maize stalk)	S	yes	2.0	12.18	1.16	n.s.	1.68	49.70
	Maize	MF+BC	BC(maize stalk)	S	yes	4.0	12.60	1.20	n.s.	2.10	31.06
	Maize	MF+BC	BC(rice straw)	S	yes	2.0	12.36	1.18	n.s.	1.86	55.03
	Maize	MF+BC	BC(rice straw)	S	yes	4.0	12.96	1.23	n.s.	2.46	36.39
	Peanut	MF		S	yes		4.20				
	Peanut	MF+BC	BC(maize stalk)	S	yes	2.0	4.68	1.11	n.s.	0.48	113.76
	Peanut	MF+BC	BC(maize stalk)	S	yes	4.0	5.10	1.21	n.s.	0.90	106.65
	Peanut	MF+BC	BC(rice straw)	S	yes	2.0	4.98	1.19	n.s.	0.78	184.86
	Peanut	MF+BC	BC(rice straw)	S	yes	4.0	5.22	1.24	n.s.	1.02	120.87
	Sweet potato	MF		S	yes		33.0				
	Sweet potato	MF+BC	BC(maize stalk)	S	yes	1.0	39.6	1.20	n.s.	6.60	

Ref. No.	Crop	Variant ^a	Treatment, plot, site, year	Single/Multiple (year) ^b	N ferti-lizing ^c (kg N/ha)	Biochar added (Mg/ha)	Yield (Mg/ha)	Rel. Yield	Signifi-cance ^d	Yield change ^e (Mg/ha)	Revenue ^e (USD/ Mg BC)
45 cont'd	Sweet potato	MF+BC	BC(rice straw)	S	yes	2.0	37.6	1.14	n.s.	4.62	
	Sweet potato	MF+BC	BC(rice straw)	S	yes	4.0	38.9	1.18	n.s.	5.94	
	Wheat	MF		S	yes		7.16				
	Wheat	MF+BC	BC(maize stalk)	S	yes	2.0	8.60	1.20	n.s.	1.44	68.21
	Wheat	MF+BC	BC(maize stalk)	S	yes	4.0	6.90	0.96	n.s.	-0.26	-6.16
	Wheat	MF+BC	BC(rice straw)	S	yes	2.0	7.70	1.08	n.s.	0.54	25.58
	Wheat	MF+BC	BC(rice straw)	S	yes	4.0	9.00	1.26	n.s.	1.84	43.58
46	Rice	C		S	0		8.6				
	Rice	BC	BC10	S	0	10.0	9.6	1.12	*	1.00	33.00
	Rice	BC	BC40	S	0	40.0	9.8	1.14	*	1.20	9.90
	Rice	MF		S	300		9.1				
	Rice	MF+BC	BC10	S	300	10.0	9.9	1.09	*	0.80	26.40
	Rice	MF+BC	BC40	S	300	40.0	10.2	1.12	*	1.10	9.08
47	Rice	C		S	0		6.28				
	Rice	BC	BC20	S	0	20.0	7.27	1.16	*	0.99	2.93
	Rice	BC	BC40	S	0	40.0	6.74	1.07	*	0.46	0.68
	Rice	MF		S	300		6.65				
	Rice	MF+BC	BC20	S	300	20.0	7.86	1.18	*	1.21	3.58
	Rice	MF+BC	BC40	S	300	40.0	7.42	1.12	*	0.77	1.14
48	Rice	MF	Year 1	Y1	300		7.6				
	Rice	MF+BC	Year 1	Y1	300	10.0	8.3	1.09	n.s.	0.70	23.10
	Rice	MF+BC	Year 1	Y1	300	20.0	8.4	1.11	n.s.	0.80	13.20
	Rice	MF+BC	Year 1	Y1	300	40.0	8.5	1.12	n.s.	0.90	7.43
	Rice	MF	Year 2	Y2	300		7.6				
	Rice	MF+BC	Year 2	Y2	300	0	9.7	1.28	*	2.10	69.30
	Rice	MF+BC	Year 2	Y2	300	0	8.3	1.09	n.s.	0.70	11.55
	Rice	MF+BC	Year 2	Y2	300	0	9.3	1.22	*	1.70	14.03

Grey shaded lines: variants without biochar added, serve as reference value for calculation of relative yield and yield difference of variants with biochar added in following (white) lines

- a) C: control (no treatment), BC: biochar, MF: mineral fertilizer (nitrogen amount see coloum N fertilizing), PF: phosphate fertilizer, Man: manure, Com: compost, Dig: digestate, Mic: inoculted with microbes.
- b) S: singe year result; Y1, Y2, Y3, Y4, Y5: no. of year of multi-year results.
- c) Amount of mineral nitrogen fertilizer applied.
- d) Significance according to original publication, *: significant (various p-levels), n.s.: not significant.
- e) Absolute yield change and revenue calculated only for crops with a market price. Revenue = (Yield change * market price) / Biochar added; market prices ref. Table S3
- f) BC quantities "whole plot rates" used.
- g) Pot experiment under field conditions; results for biochar applicationrate of 300 Mg/ha not respected .
- h) Planted in wholes, areal biochar application amounts to 0.8 and 4 t/ha, respectively, which "corresponds to 6 and 30 t/ha in conventional farming" (Cornelissen *et al.*, 2013).
- i) Variant "annually 1 t biochar" not accounted.
- k) For calculation of multiple-year revenue only data for main crops respected.
- l) Mineral nitrogen fertilizing amount not specified for some sites: "Usual application of fertilizer in the agricultural context of normal farm practice" (Hammond et al., 2013); two results not respected due to an untypically very low yield of control plot.
- m) Yield results related to hectare by the authors.
- n) No harvest results in year 3.
- o) Data taken from Fig. 2; biochar was added in the season before the field study started.
- p) Tomato fresh fruit marketable produktion
- q) No information given on harvested plant matter (grain, fresh matter).
- r) Mineral fertilizer added to all variants, but quantity not specified.

References to Table S1

- 1 Abukari A. *Effect of rice husk biochar on maize productivity in the Guinea savannah zone of Ghana*. MSc-Thesis, Faculty Renewable Natural Resources, Univ. Science and Technology, Kumasi, Ghana, 116 p (2014).
- 2 Agegnehu G, Bass AM, Nelson PN, Bird MI. Benefit of biochar, compost and biochar-compost for soil quality, maize yield and greenhouse gas emissions in a tropical agricultural soil. *Science Total Environment* 543, 295-306 (2016).
- 3 Arif M, Ali A, Umair M, Munsif F, Ali K, Inamullah MS, Ayub G. Effect of biochar FYM and mineral nitrogen alone and in combination on yield and yield components of maize. *Sarhad Journal Agriculture* 28, 191–195 (2012).
- 4 Asai H, Samson BK, Stephan HM, Songyikhangsuthor K et al. Biochar amendment techniques for upland rice production in Northern Laos: 1. Soil physical properties, leaf SPAD and grain yield. *Field Crops Research* 111, 81–84 (2009).
- 5 Baronti S, Alberti G, Delle Vedove G, Di Gennaro F, Fellet G et al. The biochar option to improve plant yields: first results from some field and pot experiments in Italy. *Italian Journal Agronomy* 5, 3-11 (2010).
- 6 Bass AM, Bird MI, Kay G, Muirhead B. Soil properties, greenhouse gas emissions and crop yield under compost, biochar and co-composted biochar in two tropical agronomic systems. *Science Total Environment* 550, 459-470 (2016),
- 7 Blackwell P, Krull E, Butler G, Herbert A, Solaiman Z. Effect of banded biochar on dryland wheat production and fertiliser use in south-western Australia: an agronomic and economic perspective. *Australian J. Soil Res.* 48, 531–545 (2010).
- 8 Borchard N, Siemens J, Ladd B, Möller A, Amelung W. Application of biochars to sandy and silty soil failed to increase maize yield under common agricultural practice. *Soil Tillage Research* 144, 184-194 (2014).
- 9 Cornelissen G, Martinsen V, Shitumbanuma V, Alling V et al. Biochar effect on maize yield and soil characteristics in five conservation farming sites in Zambia. *Agronomy* 3, 256-274 (2013).
- 10 Cui L, Pan G, Li L, Yan J, Zhang A, Bian B, Chang R. The reduction of wheat Cd uptake in contaminated soil via biochar amendment: A two-year field experiment. *BioResources* 7(4), 5666-5676 (2012).
- 11 Curaqueo G, Meier S, Khan N, Cea M, Navia R. Use of biochar on two volcanic soils: effects on soil properties and barley yield. *J. Soil Science Plant Nutrition* 14(4), 911-924 (2014).
- 12 Farrell M, Macdonald LM, Butler G, Chirino-Vallee I, Condon LM. Biochar and fertilizer application influence phosphorus fractionation and wheat yield. *Biol Fertil Soils* 50, 169-178 (2014).
- 13 Gajić A, Koch KH. Sugar Beet (*Beta vulgaris* L.) Growth Reduction Caused by Hydrochar Is Related to Nitrogen Supply. *Journal Environmental Quality* 41, 1067-1075 (2012).
- 14 Gaskin JW, Speir RA, Harris K, Das KC et al. Effect of Peanut Hull and Pine Chip Biochar on Soil Nutrients, Corn Nutrient Status, and Yield. *Agronomy Journal* 102(2), 623-633 (2010).

- 15 Glaser B, Wiedner K, Seelig S, Schmidt HP, Gerber H. Biochar organic fertilizers from natural resources as substitute for mineral fertilizers. *Agron. Sustain. Dev.* 35, 667-678 (2015).
- 16 Golika B, Baskar K. Influence of biochar as a soil amendment on yield and quality of maize in alfisol of Thoothukudi district of Tamilnadu, India. *Internat. J. Plant Animal Environm. Sci.* 5(1), 152-155 (2015).
- 17 Güereña D, Lehmann J, Hanley K, Enders A, Hyland C, Riha S. Nitrogen dynamics following field application of biochar in a temperate North American maize-based production system. *Plant Soil* 365(1-2), 239-254 (2013).
- 18 Haeefe SM, Konboon Y, Wongboon W, Amarante S, Maarifat AA, Pfeiffer EM, Knoblauch C. Effects and fate of biochar from rice residues in rice-based systems. *Field Crops Research* 121(3), 430-440 (2011).
- 19 Hall DJW, Bell RW. Biochar and Compost Increase Crop Yield but the Effect is Short Term on Sandplain Soils of Western Australia. *Pedosphere* 25(5), 720-728 (2015).
- 20 Hammond J, Shackley S, Prendergast-Millera M, Cooka J, Buckinghamb S, Pappab VA. Biochar field testing in the UK: outcomes and implications for use. *Carbon Management* 4(2), 159-170 (2013).
- 21 Islami T, Guritno B, Basuki N, Suryanto Islami A. Maize yield and associated soil quality changes in cassava+ maize intercropping system after 3 years of biochar application. *Journal Agriculture Food Technology* 1(7), 112-115 (2011).
- 22 Jay CN, Fitzgerald JD, Hipps NA, Atkinson CJ. Why short-term biochar application has no yield benefits: evidence from three field-grown crops. *Soil Use Management* 31, 241-250 (2015).
- 23 Jones DL, Rousk J, Edwards-Jones G, DeLuca TH, Murphy DV. Biochar-mediated changes in soil quality and plant growth in a three year field trial. *Soil Biology Biochemistry* 327, 235-246 (2012).
- 24 Karer J, Wimmer B, Zehetner F, Kloss S, Soja G. Biochar. application to temperate soils: effects on nutrient uptake and crop yield under field conditions. *Agricultural Food Science* 22(4), 390-403 (2013).
- 25 Kimetu JM, Lehmann J, Ngoze SO, Mugendi DN *et al.* Reversibility of Soil Productivity Decline with Organic Matter of Differing Quality Along a Degradation Gradient. *Ecosystems* 11, 726-739 (2008).
- 26 Lentz RD, Ippolito JA. Biochar and manure affect calcareous soil and Maize silage nutrient concentrations and uptake. *Journal Environmental Quality* 41(4), 1033-1043 (2012).
- 27 Liu XY, Qu JJ, Li LQ, Zhang AF *et al.* Can biochar amendment be an ecological engineering technology to depress N₂O emissions in rice paddies? – A cross site field experiment from South China. *Ecological Engineering* 42, 168-173 (2012).
- 28 Liu X, Ye Y, Liu Y, Zhang A, Zhang X *et al.* Sustainable biochar effects for low carbon crop production: A 5-crop season field experiment on a low fertility soil from Central China. *Agricultural Systems* 129, 22-29 (2014a).
- 29 Liu Z, Chen X, Jing Y, Li Q, Zhang J, Huang Q. Effect of biochar amendment on rapeseed and sweet potato yields and water stable aggregates in upland red soil. *Catena* 123, 45-51 (2014b)

- 30 Major J, Rondon M, Molina D, Riha SJ, Lehmann J. Maize yield and nutrition during 4 years after biochar application to a Colombian savanna oxisol. *Plant Soil* 333(1), 117–128 (2010).
- 31 Mokry M. *CarboSolum – Schlussbericht*. LTZ Augustenberg, Karlsruhe, Germany, 20 p. (2015).
- 32 Nehls T. *Fertility improvement of a Terra Firme Oxisol in central Amazonia by charcoal applications*. Final thesis, Geoecology, University of Bayreuth, Germany (2002).
- 33 Nellisen V, Ruyschaert G, Abusie DM, D'Hose T et al. Impact of woody biochar on properties of a sandy loam soil and spring barley during a two-year field experiment. *European Journal Agronomy* 62, 65-78 (2015).
- 34 Rogovska N, Laird DA, Rathke SJ, Karlen DL. Biochar impact on Midwestern Mollisols and maize nutrient availability. *Geoderma* 230-231, 340-347 (2014).
- 35 Sinclair K, Slavich P, Van Zwieten L, Downie A. Productivity and nutrient availability on a ferrosol: Biochar, lime and fertiliser. *Proceedings of the 24th Annual Conference of the Grassland Society of NSW*, 119-122 (2008) <http://grasslandnsw.com.au/news/wp-content/uploads/2009/10/Sinclair-Slavich-van-Zweiten-Downie-2009.pdf> (2015).
- 36 Solaiman Z, Blackwell P, Abbott L, Storer P. Direct and residual effect of biochar application on mycorrhizal root colonization, growth and nutrition of wheat. *Australian J. Soil Res.* 48, 546-554 (2010).
- 37 Steiner C, Teixeira GW, Lehmann J, Nehls T, de Macêdo JLV, Blum WEH, Zech W. Long term effects of manure, charcoal and mineral fertilization on crop production and fertility on a highly weathered Central Amazonian upland soil. *Plant Soil* 291(1), 275–290 (2007).
- 38 Suddick E, Six J. An estimation of annual nitrous oxide emissions and soil quality following the amendment of high temperature walnut shell biochar and compost to a small scale vegetable crop rotation. *Science Total Environment* 465, 298-307 (2013).
- 39 Sukartono WHU, Kusuma Z, Nugroho WH (2011) Soil fertility status, nutrient uptake, and maize (*Zea mays* L.) yield following biochar and cattle manure application on sandy soils of Lombok, Indonesia. *Journal Tropical Agriculture* 49(1-2), 47-52.
- 40 Tammeorg P, Simojoki A, Mäkelä P, Stoddard FL, Alakukku L, Helenius J. Short-term effects of biochar on soil properties and wheat yield formation with meat bone meal and inorganic fertiliser on a boreal loamy sand. *Agriculture Ecosystems Environment* 191, 108-116 (2014).
- 41 Tammeorg P, Simojoki A, Mäkelä P, Stoddard FL, Alakukku L, Helenius J. Biochar application to a fertile sandy clay loam in boreal conditions: effects on soil properties and yield formation of wheat, turnip rape and faba bean. *Plant Soil* 374(1-2), 89-107 (2014).
- 42 Vaccari FP, Baronti S, Lugato E, Genesio L, Castaldi S, Fornasier F, Miglietta F. Biochar as a strategy to sequester carbon and increase yield in durum wheat. *European Journal Agronomy* 34(4), 231–238 (2011).
- 43 Vaccari FP, Maienza A, Miglietta F, Baronti S et al. Biochar stimulates plant growth but not fruit yield of processing tomato in fertile soil. *Agriculture, Ecosystems Environment* 207, 163-170 (2015).

- 44 Yamato M, Okimori Y, Wibowo IF, Anshori S, Ogawa M. Effects of the application of charred bark of *Acacia mangium* on the yield of maize, cowpea and peanut, and soil chemical properties in South Sumatra, Indonesia. *Soil Science Plant Nutrition* 52(4), 489–495 (2006).
- 45 Yang Y, Ma S, Zhao Y, Jing M, Xu Y, Chen J. A Field Experiment of Enhancement of Crop Yield by Rice Straw and Maize Stalk-Derived Biochar in Northern China. *Sustainability* 7, 13713-13725 (2015).
- 46 Zhang A, Cui L, Pan G, Li L, Hussain Q, Zhang X, Zheng J, Crowley D. Effect of biochar amendment on yield and methane and nitrous oxide emissions from a rice paddy from Tai Lake plain, China. *Agriculture Ecosystems Environment* 139(4), 469–475 (2010).
- 47 Zhang A, Liu Y, Pan G, Hussain Q, Li L, Zheng J, Zhang X. Effect of biochar amendment on maize yield and greenhouse gas emissions from a soil organic carbon poor calcareous loamy sand from Central China Plain. *Plant Soil* 351, 263-275 (2012).
- 48 Zhang A, Bian R, Pan G, Cui L, Hussain Q, Li L, Zheng J et al. Effects of biochar amendment on soil quality, crop yield and greenhouse gas emission in a Chinese rice paddy: A field study of 2 consecutive rice growing cycles. *Field Crops Research* 127, 153–160 (2012).

Table S2. Quantiles of absolute and relative change in crop yield (data of Table S1) from field experiments of biochar application to agricultural crops.

Crop	Quantile					n
	5%	25%	50%	75%	95%	
	----- Relative yield change (-) ^a -----					
Maize ^c	0.761	0.968	1.075	1.290	2.203	168
Cereals ^{c,d}	0.828	0.949	1.013	1.090	1.393	135
Rice ^c	0.717	0.964	1.037	1.133	1.320	81
Other crops ^e	0.598	0.944	1.028	1.202	1.782	123
All crops	0.718	0.950	1.028	1.177	1.705	507
	----- Absolute yield change (Mg ha ⁻¹) ^b -----					

Maize ^c	-1.81	-0.33	0.34	1.20	2.60	168
Cereals ^{c,d}	-0.48	-0.14	0.04	0.26	0.74	135
Rice ^c	-0.80	-0.12	0.10	0.50	1.00	81
Other crops ^f	-8.42	-0.20	0.29	1.21	5.14	117

^a) Yield of variant ‘with biochar’ relative to yield of control (without biochar).

^b) Yield of variant ‘with biochar’ minus yield of control (without biochar).

^c) Yield of maize, cereals (not including maize), and rice is given as grain yield.

^d) All other cereals not including maize.

^e) Other crop: crop type is specified in Table S1.

^f) Quantiles of absolute yield change for ‘other crops’ should be interpreted carefully due to the varying harvested crop parts as well as figures given for dry and fresh matter yield, respectively, for different crops.

Table S3. Crop market prices used for calculation of revenue.

Crop	Market price	Source
	USD t ⁻¹	
Corn	59	U.S. crop farm prices 2014/15
Wheat, winter	95	U.S. crop farm prices 2014/15
Rice, medium	330	U.S. crop farm prices 2014/15
Hirse	64	U.S. crop farm prices 2014/15
Gerste	85	U.S. crop farm prices 2014/15
Rapeseed	523	U.S. crop farm prices 2014/15
Groundnut	474	U.S. crop farm prices 2014/15
Dry peas	261	U.S. crop farm prices 2014/15
Sunflower seed	456	U.S. crop farm prices 2014/15
Potatoes	181	www.usda.gov/nass/PUBS/TODAYRPT/agpr1215.pdf
Lupin grain	200	www.igrain.com.au/
Sugar beet	33,4	Notation Germany 2015

References for Table S3

April 2015 U.S. Crop Price Update. FAPRI-MU Bulletin #08-15. Food and Agricultural Policy Research Institute (FAPRI), University of Missouri (MU), Columbia, MO.

Notation Germany 2015; www.liz-online.de/meldungen/alle/datum/2015/02/25/die-ruebenpreise-2014-2015-stehen-fest.html (exchange rate USD / EURO = 1.10)

Table S4. Median and quantiles of the revenue of biochar application to soils (data of Table S1).

Crop	Quantile					n
	5%	25%	50%	75%	95%	
	----- Revenue (USD/Mg biochar) ^c -----					
Maize ^a	-4.64	1.22	9.76	20.54	35.77	51
Cereals ^{a,d}	-98.53	-0.79	2.99	10.33	45.57	54
Rice ^a	-87.41	-8.25	0.50	12.38	33.00	53
Other crops ^a	-301.02	-193.14	10.80	60.67	123.08	21
Multi-year results ^b	-7.62	-1.89	0.32	2.76	11.39	93
All results	-93.43	-1.77	1.57	10.74	44.76	272

^a) Single year results.

^b) 2–5 year results, revenue averaged.

^c) Note: Revenues are calculated as annual value, for complete evaluation on biochar profitability the annual revenue has to be multiplied by the expected number of years of biochar effectiveness.

^d) Cereals not including maize.

Table S5. Half-lives of biochars from soil incubation experiments.

Ref. No.	Conversion method, highest treatment temperature, feedstock	Variants	Factors	Measuring period (d)	Half life time (yr)	Note
Pyrolytic or thermally produced biochars						
1	Pyrolysis, 575 °C, Miscanthus	Sandy soil		200	>1000	a
		Loamy sand		200	16.8	a
2	Pyrolysis, PYREG, 650 °C, Miscanthus	Sandy soil		196	51.7	a
		Loamy sand		196	58.9	a
	Pyrolysis, CarboTerra, 550 °C, Maize cob	Sandy soil		196	7.6	a
		Loamy sand		196	7.1	a
	Pyrolysis, UK BRC, 500 °C, Miscanthus	Sandy soil		196	12.7	a
		Loamy sand		196	10.1	a
3	Pyrolysis Centrifuge Reactor (PCR), five temperatures, Wheat straw	T = 475 °C		115	1.7	h
		T = 500 °C		115	2.8	h
		T = 525 °C		115	4.4	h
		T = 550 °C		115	5.2	h
		T = 575 °C		115	6.0	h
4	Slow pyrolysis, 550 °C, two feedstocks	Green waste		60	21.2	
		Poultry manure		60	1.7	
6	Slow Pyrolysis, two temperatures, Woody biomass (Eucalyptus)	Inceptosol	T = 450 °C	730	91	b,c
			T = 550 °C	730	505	b,c
		Entisol	T = 450 °C	730	0.3	b,c
			T = 550 °C	730	358	b,c
		Oxisol	T = 450 °C	730	0.3	b,c
			T = 550 °C	730	330	b,c

Ref. No.	Conversion method, highest treatment temperature, feedstock	Variants	Factors	Measuring period (d)	Half life time (yr)	Note
6		Vertisol	T = 450 °C	730	26	b,c
cont'd			T = 550 °C	730	363	b,c
8	Thermally altered, three feedstocks	Maize, T = 350 °C		60	14.8	d
		Rye, T = 350 °C		60	16.0	d
		Wood, T = 800 °C		60	44.6	d
9	Pyrolysis, two temperatures	Alfisol	T = 350 °C	510	8.1	e,f
			T = 550 °C	510	50	e,f
	Maize stover	Andisol	T = 350 °C	510	44	e,f
			T = 550 °C	510	43	e,f
10	Pyrogenic organic material (oxic conditions), 350 °C,	Rye grass	1 min charred (oxic cond.)	48	13.8	a
			4 min charred (oxic cond)	48	19.8	a
11	two feedstocks	Pine wood	1 min charred (oxic cond.)	850	3.5	a
			4 min charred (oxic cond)	850	3.6	a
12	Slow pyrolysis, woody biomass, two tempratures	0 % LOM added	T = 450 °C	120	43	a
		(labile organic matter)	T = 550 °C	120	69	a
		1 % LOM	T = 450 °C	120	78	a
			T = 550 °C	120	122	a
		2 % LOM	T = 450 °C	120	51	a
			T = 550 °C	120	172	a
		4 % LOM	T = 450 °C	120	62	a
			T = 550 °C	120	71	a
13	Pyrolysis, 400 °C, Perennial ryegrass	Loess soil		3100	278	a
		Sandy soil		3100	(278)	g

Ref. No.	Conversion method, highest treatment temperature, feedstock	Variants	Factors	Measuring period (d)	Half life time (yr)	Note
14	Pyrolysis (Carbolite CWF 1200), two temperatures, Miscanthus straw	T = 350 °C	soil pH 4	187	19.3	d
			soil pH 8	187	14.9	d
		T = 350 °C + ryegrass	soil pH 4	187	19.9	d
			soil pH 8	187	9.3	d
		T = 700 °C	soil pH 4	187	59.6	d
			soil pH 8	187	55.7	d
		T = 700 °C + ryegrass	soil pH 4	187	21.4	d
			soil pH 8	187	19.3	d
15	Pyrolysis, ca 400-600 °C, Mango pruning			730	62	d
17	Pyrolysis, 550 °C, two feedstocks	Tomato green waste 2%	Solonetz	120	46	e
			Ferralsol	120	15	e
		Tomato green waste 4%	Solonetz	120	44	e
			Ferralsol	120	23	e
		Blue malley 2%	Solonetz	120	1038	e
			Ferralsol	120	186	e
		Blue malley 4%	Solonetz	120	554	e
			Ferralsol	120	138	e
18	Gasification, 1200 °C, Maize silage	Fresh		222	73.6	a
		Physically weathered		222	145	a
19	Pyrolysis, two temperatures, two feedstocks, three water regimes	Maize residue, T = 350 °C	Unsaturated	365	2.9	h
			Saturated	365	6.0	h
			Alternating	365	4.2	h
		T = 600 °C	Unsaturated	365	5.8	h
			Saturated	365	7.0	h

Ref. No.	Conversion method, highest treatment temperature, feedstock	Variants	Factors	Measuring period (d)	Half life time (yr)	Note
19	cont'd	Oak wood, T = 350 °C	Alternating	365	6.3	h
			Unsaturated	365	8.2	h
			Saturated	365	10.9	h
		T = 600 °C	Alternating	365	4.6	h
			Unsaturated	365	7.4	h
			Saturated	365	7.7	h
			Alternating	365	6.7	h
20	Kiln, ca. 500-600 °C, Wheat straw	50 Mg/ha biochar		98	133	h
		100 Mg/ha biochar		98	116	h
21	Charcoal, 550 °C, Wood	Ferralsol		365	36.5	a
		Luvisol topsoil		365	9.5	a
		Luvisol subsoil		365	11.4	a
	Low temp. thermocatalytic conversion, 400 °C Sewage sludge	Ferralsol		365	19.6	a
		Luvisol topsoil		365	19.0	a
		Luvisol subsoil		365	19.0	a
22	Pyrolysis, two temperatures, five feedstocks	Blue gum wood	T = 400 °C, activated	1829	226	a
			T = 550 °C, activated	1170	881	a
			T = 400 °C, non-activated	1829	204	a
			T = 550 °C, non-activated	1829	1120	a
		Blue gum leaves	T = 400 °C, activated	1829	187	a
			T = 550 °C, activated	1829	396	a
		Paper sludge	T = 550 °C, activated	1829	274	a
		Poultry manure	T = 400 °C, non-activated	1829	89	a
			T = 550 °C, activated	1829	217	a

Ref. No.	Conversion method, highest treatment temperature, feedstock	Variants	Factors	Measuring period (d)	Half life time (yr)	Note
22	cont'd	Cow manure	T = 400 °C, non-activated	1829	62	a
			T = 550 °C, activated	1829	881	a
24	Pyrolysis, two feedstocks	Yeast-derived biochar	Arable soil	175	29	a
			Forest soil	175	6.0	a
		Glucose-derived biochar	Arable soil	175	4.0	a
			Forest soil	175	12	a
25	Pyrolysis, 1200 °C, Maize pellets	Untrenchend soil	Italy	245	5.2	a
			UK	164	4.8	a
26	Pyrolysis, 450 °C, Maize straw	0.83% biochar added	75 % field capacity	1095	14.1	d
			100 % field capacity	1095	10.5	d
		3.0 % biochar added	75 % field capacity	1095	15.8	d
			100 % field capacity	1095	16.7	d
Pyrolytic biochars in artificial incubation substrate						
27	Pyrolysis, three to five temperatures six feedstocks	Bubinga	T = 250 °C	365	1203	a,i
			T = 400 °C	365	4296	a,i
			T = 650 °C	365	15558	a,i
		Cedar	T = 250 °C	365	733	a,i
			T = 400 °C	365	23815	a,i
			T = 650 °C	365	2*10 ⁷	a,i
		Grass	T = 250 °C	365	263	a,i
			T = 400 °C	365	373	a,i
			T = 650 °C	365	152	a,i
		Oak	T = 250 °C	365	843	a,i
			T = 400 °C	365	1021	a,i

Ref. No.	Conversion method, highest treatment temperature, feedstock	Variants	Factors	Measuring period (d)	Half life time (yr)	Note
27	cont'd		T = 650 °C	365	96169	a,i
		Pine	T = 400 °C	365	6786	a,i
			T = 650 °C	365	3643	a,i
		Sugar cane	T = 250 °C	365	691	a,i
			T = 400 °C	365	9306	a,i
			T = 650 °C	365	140000	a,i
Hydrothermally carbonized biochars						
1	HTC, 180 °C		Sandy soil	200	1.0	a
	Miscanthus		Loamy sand	200	1.2	a
2	HTC, Artec GmbH, two temperatures, Maize silage	T = 180 °C	Sandy soil	196	1.3	a
			Loamy sand	196	1.0	a
		T = 230 °C	Sandy soil	196	4.6	a
			Loamy sand	196	3.2	a
	HTC, HS OWL, 180 °C, Maize silage	Fresh biochar	Sandy soil	196	1.6	a
			Loamy sand	196	1.7	a
		Washed biochar	Sandy soil	196	1.6	a
			Loamy sand	196	1.5	a
	HTC, Fa. Schlitt 200 °C, Maize silage		Sandy soil	196	1.2	a
			Loamy sand	196	1.3	a
	HTC, MPI Potsdam, 200°C, Maize silage		Sandy soil	196	6.5	a
			Loamy sand	196	5.8	a
5	HTC, 230 °C, Two feedstocks	Wheat straw	Topsoil	500	13.3	e
			Subsoil	500	18.0	e
		Wheat straw + digestate	Topsoil	500	13.8	e

Ref. No.	Conversion method, highest treatment temperature, feedstock	Variants	Factors	Measuring period (d)	Half life time (yr)	Note
5 cont'd			Subsoil	..500	20.3	e
7	HTC, three temperatures two durations, two feedstocks	Draff	T = 180 °C, 4 h T = 180 °C, 12 h T = 200 °C, 4 h	248 248 248	0.5 0.9 0.9	a a a
		Sugarbeet pulp	T = 250 °C, 4 h T = 180 °C, 4 h T = 180 °C, 12 h T = 200 °C, 4 h T = 250 °C, 4 h	248 248 248 248 248	1.7 0.5 0.7 0.5 1.8	a a a a a
16	HTC, 230 °C, Maize silage	Coarse soil Fine soil		365 365	8.8 (8.8)	a k
18	HTC, 250 °C, Maize silage	fresh physically weathered		196 196	8.4 10.4	a a
21	HTC, 200 °C Bark	Ferralsol Luvisol topsoil Luvisol subsoil		365 365 365	19.0 6.3 9.5	a a a
22	HTC two feedstocks three temperatures (for straw digestate)	Poplar Straw digestate	T = 230 °C, washed T = 210 °C, washed T = 230 °C, washed T = 250 °C, washed T = 210 °C, unwashed T = 230 °C, unwashed T = 250 °C, unwashed	120 120 120 120 120 120 120	9.2 2.6 9.3 9.4 2.3 6.2 9.4	e,l e,l e,l e,l e,l e,l e,l

- a) Half-life ($t_{1/2}$), mean residence time (MRT), or decay rate (k) is specified in the publication.
- b) $t_{1/2}$ calculated by the authors with a two component (double exponential) decomposition model based on the published data on carbon loss over time.
- c) Only variants with 20 °C incubation temperature accounted for statistical analysis.
- d) $t_{1/2}$ calculated by the authors with a one component (single exponential) decomposition model based on the published data on carbon loss over time.
- e) $t_{1/2}$ calculated by the authors based on published parameters of the respective decomposition model (one, two, or three components).
- f) $t_{1/2}$ calculated with parameters of a three component model (standardized for 19 °C).
- g) Exact result not given, but reported in the text as very similar to the loess variant.
- h) $t_{1/2}$ calculated by the authors with a one component (single exponential) model based on published C loss at the end of measurement period.
- i) Data of Zimmermann (2010) additionally reported but not accounted for statistical analysis of half-life quantiles due to the artificial.
- k) Half-life for variant fine soil not explicitly reported, but stated as nearly identical to variant coarse soil.
- l) 5 variants with recirculated process liquor not respected.

References for Table S5

- 1 Bai M, Wilske B, Buegger F *et al.* Degradation kinetics of biochar from pyrolysis and hydrothermal carbonization in temperate soils. *Plant Soil* 372, 375–387 (2013).
- 2 Bai M, Wilske B, Bach M, Breuer L. *Entwicklung eines Routineverfahrens zur Bestimmung der Abbaurate von Biokohlen im Boden* Development of a routine procedure for determination of biochar decomposition rate in soils. Final Report, Deutsche Bundesstiftung Umwelt, Osnabrück, Germany, Project No. 29031(2014).
- 3 Bruun EW, Hauggaard-Nielsen H, Ibrahim I, Egsgaard H *et al.* Influence of fast pyrolysis temperature on biochar labile fraction and short-term carbon loss in a loamy soil. *Biomass Bioenergy* 35(3), 1182–1189 (2011).
- 4 Cayuela ML, Oenema O, Kuikman PJ, Bakker RR, van Groenigen, JW. Bioenergy by-products as soil amendments? Implications for carbon sequestration and greenhouse gas emissions. *GCB Bioenergy* 2, 201–213 (2010).
- 5 Dicke C, Lanze G, Mumme J, Ellerbrock R, Kern J. Effect of Hydrothermally carbonized char application on trace gas emission from two sandy soils. *J. Environmental Quality* 43, 1790–1798 (2014).
- 6 Fang Y, Singh B, Singh BP, Krull E. Biochar carbon stability in four contrasting soils. *European Journal Soil Science* 65, 60–71 (2014).
- 7 Gajic A, Ramke HR, Hendricks A, Koch HJ. Microcosm study on the decomposability of hydrochars in a Cambisol. *Biomass Bioenergy* 47, 250–259 (2012).
- 8 Hamer U, Marschner B, Brodowski S, Amelung W. Interactive priming of black carbon and glucose mineralization. *Organic Geochemistry* 35, 823–830 (2004).
- 9 Herath HMS, Herath K, Camps-Arbestain M, Hedley MJ, Kirschbaum MUF, Wang T, van Hale R. Experimental evidence for sequestering C with biochar by avoidance of CO₂ emissions from original feedstock and protection of native soil organic matter, *GCB Bioenergy*, DOI: 10.1111/gcbb.12183 (2014).
- 10 Hilscher A, Heister K, Siewert C, Knicker H. Mineralisation and structural changes during the initial phase of microbial degradation of pyrogenic plant residues in soil. *Organic Geochemistry* 40, 332–342 (2009).
- 11 Hilscher A, Knicker. Biochar mineralization and priming effect on SOM decomposition in two European short rotation coppices. *Organic Geochemistry* 42, 42–54 (2011).
- 12 Keith A, Singh B, Singh BP. Interactive Priming of Biochar and Labile Organic Matter Mineralization in a Smectite-Rich Soil. *Environmental Science Technology* 45(22), 9611–9618 (2011)
- 13 Kuzyakov Y, Bogomolova I, Glaser B. Biochar stability in soil: Decomposition during eight years and transformation as assessed by compound-specific ¹⁴C analysis. *Soil Biology Biochemistry* 70, 229–236 (2014).
- 14 Luo Y, Durenkamp M, De Nobili M, Lin Q. Short term soil priming effects and the mineralisation of biochar following its incorporation to soils of different pH. *Soil Biology Biochemistry* 43, 2304–2314 (2011).
- 15 Major J, Lehmann J, Rondon M, Goodale C. Fate of soil-applied black carbon: downward migration, leaching and soil respiration. *Global Change Biology* 16, 1366–1379 (2010).

- 16 Malghani S, Jüschke E, Baumert J, Thuille A et al. Carbon sequestration potential of hydrothermal carbonization char (hydrochar) in two contrasting soils; results of a 1-year field study. *Biology Fertility Soils* 51, 123-134 (2015).
- 17 Murray J, Keith A, Singh B. The stability of low- and high-ash biochars in acidic soils of contrasting mineralogy. *Soil Biology Biochemistry* 89, 217–225 (2015).
- 18 Naisse C, Girardin C, R Lefevre, A Pozzi A, Maas R, Stark A. Effect of physical weathering on the carbon sequestration potential of biochars and hydrochars in soil. *GCB Bioenergy*, DOI: 10.1111/gcbb.12158 (2014).
- 19 Nguyen BT, Lehmann J. Black carbon decomposition under varying water regimes. *Organic Geochemistry* 40, 846-853 (2009).
- 20 O'Toole A, Knoth de Zarruk K, Steffens M, Rass DP. Characterization, Stability, and Plant Effects of Kiln-Produced Wheat Straw Biochar. *Journal Environmental Quality* 42, 429-436 (2013).
- 21 Qayyum MF, Steffens D, Reisenauer HP, Schubert S. Kinetics of Carbon Mineralization of Biochars Compared with Wheat Straw in Three Soils. *Journal Environmental Quality* 41, 1210-1220 (2012).
- 22 Schulze M, Mumme J, Funke A, Kern J. Effect of selected process conditions on the stability of hydrochar in low-carbon sandy soils. *Geoderma* 267, 137-145 (2016)
- 23 Singh BP, Cowie AI, Smernik RJ. Biochar carbon stability in a clayey soil as a function of feedstock and pyrolysis temperature. *Environmental Science Technology* 46, 11770-11778 (2012).
- 24 Steinbeiss S, Gleixner G, Antonietti M. Effect of biochar amendment on soil carbon balance and soil microbial activity. *Soil Biology Biochemistry* 41, 1301-1310 (2009).
- 25 Ventura M, Alberti G, Viger M, Jenkins JR. Biochar mineralization and priming effect on SOM decomposition in two European short rotation coppices. *GCB Bioenergy* 7, 1150-1160 (2015).
- 26 Zhang MK, Gu GP, Wang Y. Degradation characteristic of different biochar materials in soil environments. *Journal of Zhejiang University, Hangzhou, China (Agriculture and Life Science)* 38, 329–335 (2012).
- 27 Zimmerman AR. Abiotic and microbial oxidation of laboratory-produced black carbon (biochar). *Environmental Science Technology* 44, 1295–1301 (2010).

Table S6. Median and quantiles of biochar half-lives from soil incubation experiments (data of Table S5).

Biochar type	Quantile					n
	5%	25%	50%	75%	95%	
	----- Half-life $t_{1/2}$ (years) -----					
Pyrolysis – without data of Zimmermann (2010) ^a	3.0	8.0	20.6	89.8	547	104
Pyrolysis – including data of Zimmermann (2010)	3.5	10.1	44.1	226	6786	121
Hydrothermal biochar (HTC)	0.5	1.3	2.9	9.3	18.1	40

^a) Experimental setup of Zimmermann (2010, see ref. 27 to Table S5) did not use natural soil but pure quartz sand with microbial inoculum; estimation of $t_{1/2}$ by decay function with decay rate k declining over time.