

Potential of Biochar to Alternate Soil Properties and Crop Yields 3 and 4 Years After the Application

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SUPPLEMENTARY MATERIAL

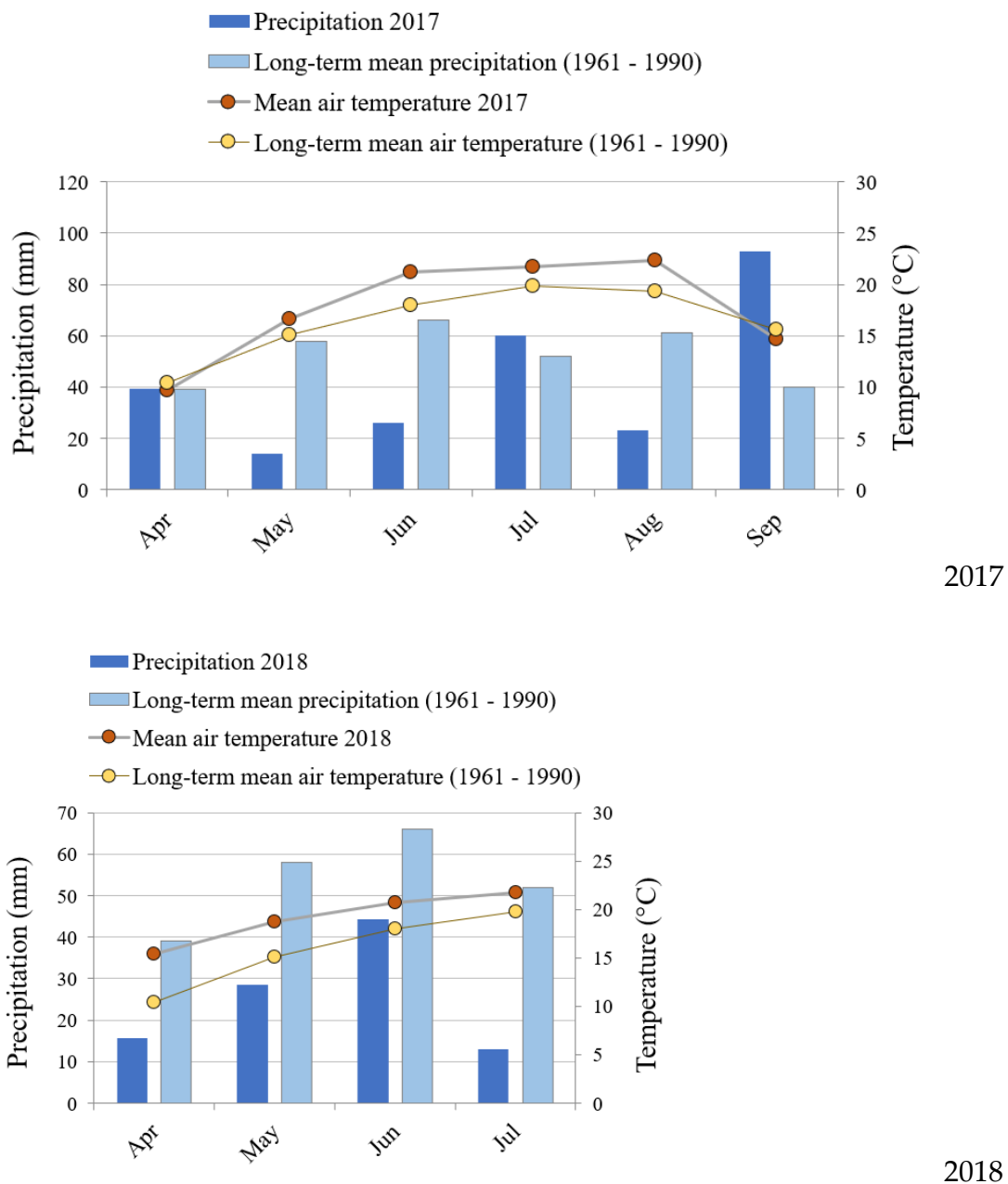


Figure S1. Monthly precipitation and mean air temperature in crop vegetation period 2017 and 2018 and according to climatic normal (1961–1990) [35].



Figure S2. Experimental site in Dolná Malanta, Slovakia with grown crops: maize in 2017 and spring barley in 2018 (Source: Aydin).

Table S1. Evaluation of monthly precipitation and mean air temperature normality in 2017 and 2018 as compared to climatic normal for 1961–1990 [35] according to methodology of Kožnarová and Klabzuba [72].

Month	Precipitation				Mean air temperature			
	2017		2018		2017		2018	
	% of normal	Interval of normality	% of normal	Interval of normality	Deviation of normal (°C)	Interval of normality	Deviation of normal (°C)	Interval of normality
I.	41	very dry	163	very wet	-7.4	very cold	4.1	very warm
II.	83	normal	84	normal	-0.6	normal	-1.3	cold
III.	33	dry	121	normal	3.7	very warm	-1.6	normal
IV.	101	normal	40	dry	-0.7	normal	5.0	extremely warm
V.	24	very dry	49	very dry	1.5	normal	3.7	extremely warm
VI.	40	very dry	67	dry	3.2	extremely warm	2.7	extremely warm
VII.	115	normal	25	very dry	1.9	very warm	1.9	very warm
VIII.	38	very dry	5	extremely dry	3.1	extremely warm	3.2	extremely warm
IX.	233	very wet	138	normal	-1.0	normal	0.8	normal
X.	139	normal	35	very dry	0.2	normal	1.9	warm
XI.	40	dry	43	dry	0.5	normal	1.2	warm
XII.	113	normal	144	wet	1.5	normal	-1.6	cold
I.–XII.	78	very dry	68	very dry	0.5	normal	1.7	extremely warm

Legend

Evaluation intervals of air temperature normality

extremely cold	very cold	cold	normal	warm	very warm	extremely warm
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Evaluation intervals of precipitation normality

extremely wet	very wet	wet	normal	dry	very dry	extremely dry
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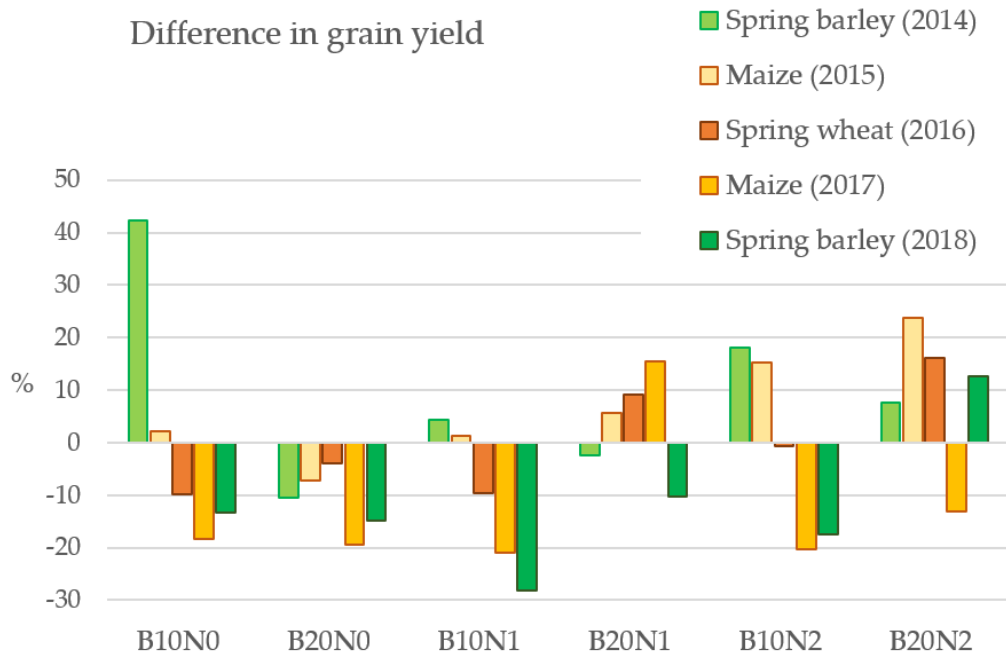
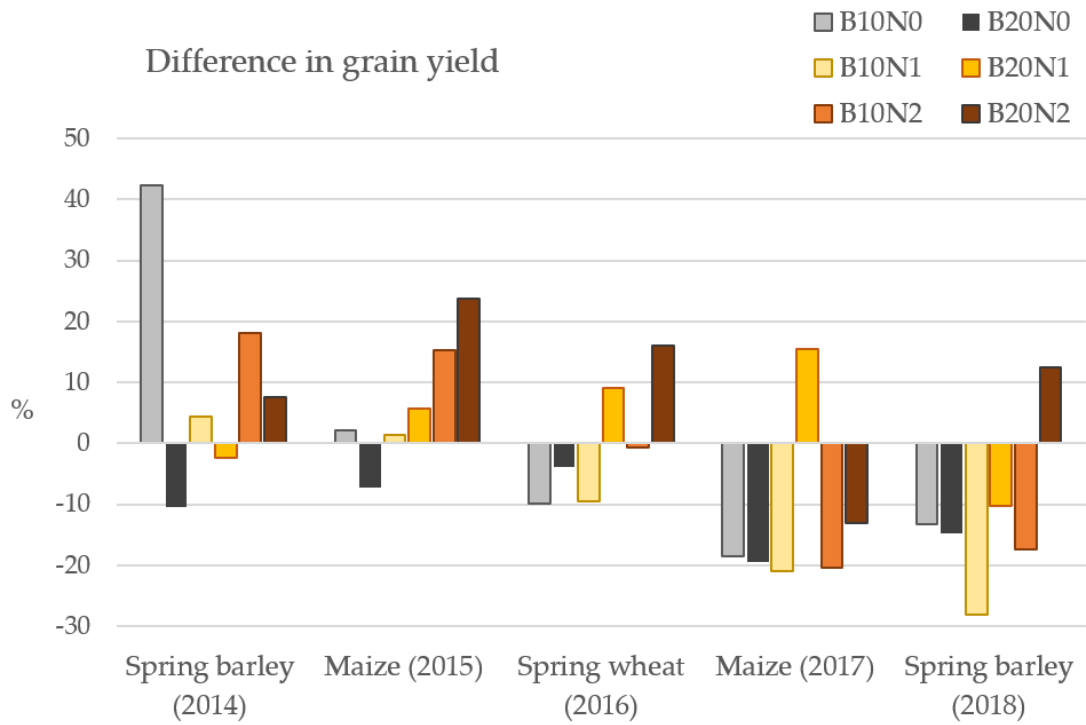


Figure S3. Differences in observed grain yield after biochar and N fertilizer application at the experimental site Dolná Malanta based on comparison to the relevant control treatments.



Table S2. Matrix of Pearson product-moment correlation coefficients and their significance for soil properties studied during vegetation season in 2017 (df = 52).

	C _{org}	C _L	HS	HA	FA	HA:FA	Q _{HS}	Q _{HA}	pH _{KCl}	Ha	SBC	CEC
CL	0.334*											
HS	-0.872***	-0.316*										
HA	-0.675***	-0.509***	0.790***									
FA	-0.732***	-0.021	0.825***	0.304*								
HA:FA	0.169	-0.354**	-0.152	0.474***	-0.673***							
Q _{HS}	-0.307*	0.136	0.164	-0.169	0.411**	-0.523***						
Q _{HA}	-0.053	0.348*	0.060	-0.225	0.302*	-0.465***	0.678***					
pH _{KCl}	0.676***	0.210	-0.729***	-0.543***	-0.631***	0.193	-0.308*	-0.186				
Ha	-0.491***	-0.074	0.599***	0.354**	0.604***	-0.282*	0.353**	0.360**	-0.846***			
SBC	0.507***	0.538***	-0.486***	-0.488***	-0.304*	-0.093	0.033	0.414**	0.559***	-0.238		
CEC	0.411**	0.532***	-0.367**	-0.422**	-0.180	-0.155	0.117	0.507***	0.388**	-0.021	0.976***	
Bs	0.630***	0.324*	-0.715***	-0.521***	-0.630***	0.180	-0.260	-0.092	0.915***	-0.882***	0.653***	0.475***

not significant
 * p ≤ 0.05
 ** p ≤ 0.01
 *** p ≤ 0.001

C_{org} – soil organic carbon
 C_L – labile carbon
 HS – humus substances
 HA – humic acids
 FA – fulvic acids
 Q_{HS} – color quotient of humus substances

Q_{HA} – color quotient of humus acids
 Ha – hydrolytic acidity
 SBC – sum of basic cations
 CEC – cation exchange capacity
 Bs – base saturation

Table S3. Matrix of Pearson product-moment correlation coefficients and their significance for soil properties studied during vegetation season in 2018 (df = 34).

	C _{org}	C _L	HS	HA	FA	HA:FA	Q _{HS}	Q _{HA}	pH _{KCl}	Ha	SBC	CEC
C _L	0.280											
HS	-0.853***	-0.109										
HA	-0.729***	-0.119	0.809***									
FA	-0.633***	-0.052	0.790***	0.279								
HA:FA	-0.045	-0.056	-0.032	0.552***	-0.627***							
Q _{HS}	-0.068	-0.588***	-0.182	-0.106	-0.190	0.070						
Q _{HA}	0.072	-0.577***	-0.317	-0.191	-0.322	0.127	0.938***					
pH _{KCl}	0.484**	0.378*	-0.529***	-0.554***	-0.282	-0.185	-0.242	-0.154				
Ha	-0.149	-0.327*	0.255	0.290	0.109	0.106	0.201	0.138	-0.871***			
SBC	0.581***	0.302	-0.592***	-0.541***	-0.397*	-0.075	-0.092	0.019	0.900***	-0.780***		
CEC	0.684***	0.256	-0.655***	-0.577***	-0.465**	-0.054	-0.037	0.080	0.804***	-0.599***	0.968***	
Bs	0.315	0.325	-0.402*	-0.402*	-0.231	-0.092	-0.166	-0.079	0.925***	-0.973***	0.891***	0.752***

not significant
 * p ≤ 0.05
 ** p ≤ 0.01
 *** p ≤ 0.001

C_{org} – soil organic carbon
 C_L – labile carbon
 HS – humus substances
 HA – humic acids
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 Q_{HS} – color quotient of humus substances

Q_{HA} – color quotient of humus acids
 Ha – hydrolytic acidity
 SBC – sum of basic cations
 CEC – cation exchange capacity
 Bs – base saturation



Table S4. Matrix of Pearson product-moment correlation coefficients and their significance for soil properties and crop yield parameters studied during vegetation season in 2017 (df = 7).

	C _{org}	CL	HS	HA	FA	HA:FA	Q _{HS}	Q _{HA}	pH _{KCl}	Ha	SBC	CEC	Bs	NP	AB	NE	GW	E/P	G/E	
CL	0.737*																			
HS	-0.943***	-0.608																		
HA	-0.925***	-0.666	0.967***																	
FA	-0.901***	-0.513	0.969***	0.875*																
HA:FA	0.320	0.020	-0.340	-0.095	-0.557															
Q _{HS}	-0.417	-0.439	0.555	0.585	0.491	0.023														
Q _{HA}	0.120	0.216	0.188	0.138	0.225	-0.086	0.599													
pH _{KCl}	0.767*	0.428	-0.838**	-0.803**	-0.819**	0.321	-0.523	-0.149												
Ha	-0.599	-0.228	0.765*	0.700*	0.780*	-0.368	0.645	0.460	-0.937***											
SBC	0.815**	0.519	-0.766*	-0.747*	-0.737*	0.300	-0.307	0.224	0.929***	-0.752*										
CEC	0.797*	0.553	-0.684*	-0.680*	-0.646	0.253	-0.168	0.418	0.833**	-0.599	0.978***									
Bs	0.734*	0.371	-0.839*	-0.789*	-0.835*	0.359	-0.580	-0.265	0.991***	-0.972***	0.879**	0.762*								
NP	0.335	-0.091	-0.367	-0.379	-0.332	-0.038	0.219	0.020	0.096	-0.043	0.116	0.125	0.109							
AB	-0.259	-0.199	0.398	0.289	0.479	-0.486	0.507	0.468	-0.641	0.749*	-0.447	-0.308	-0.668*	0.512						
NE	-0.487	-0.700*	0.525	0.580	0.438	0.028	0.511	0.084	-0.644	0.540	-0.601	-0.556	-0.614	0.211	0.479					
GW	-0.722*	-0.231	0.860**	0.753*	0.911***	-0.536	0.453	0.414	-0.689	0.743*	-0.528	-0.401	-0.726*	-0.329	0.501	0.169				
E/P	-0.647	-0.655	0.699*	0.753*	0.602	0.017	0.409	0.063	-0.701	0.571	-0.671*	-0.630	-0.676*	-0.226	0.264	0.903***	0.333			
G/E	0.710*	0.476	-0.778*	-0.778*	-0.729*	0.194	-0.444	-0.093	0.566	-0.488	0.526	0.474	0.566	0.322	-0.102	-0.526	-0.630	-0.687*		
GY	-0.180	-0.186	0.315	0.232	0.375	-0.361	0.500	0.488	-0.561	0.679*	-0.359	-0.224	-0.585	0.551	0.980***	0.431	0.421	0.192	0.036	

not significant
 * p ≤ 0.05
 ** p ≤ 0.01
 *** p ≤ 0.001

NP – number of plants
 AB – above-ground biomass
 NE – number of ears
 GW – average grain weight
 E/P – number of ears per plant
 G/E – number of grains per ear
 GY – grain yield



Table S5. Matrix of Pearson product-moment correlation coefficients and their significance for soil properties and crop yield parameters studied during vegetation season in 2018 (df = 7).

	C _{org}	CL	HS	HA	FA	HA:FA	Q _{HS}	Q _{HA}	pH _{KCl}	Ha	SBC	CEC	Bs	NP	AB	NE	GW	E/P	G/E	
CL	0.367																			
HS	-0.969***	-0.497																		
HA	-0.786*	-0.510	0.895**																	
FA	-0.963***	-0.392	0.919***	0.648																
HA:FA	0.480	0.005	-0.333	0.117	-0.673*															
Q _{HS}	-0.481	-0.599	0.628	0.625	0.520	-0.146														
Q _{HA}	0.309	-0.373	-0.102	0.191	-0.343	0.596	0.406													
pH _{KCl}	0.518	0.729*	-0.648	-0.736*	-0.457	-0.117	-0.724*	-0.537												
Ha	-0.262	-0.733*	0.424	0.592	0.201	0.310	0.653	0.669*	-0.953***											
SBC	0.680*	0.642	-0.774*	-0.793*	-0.623	0.042	-0.728*	-0.388	0.972***	-0.859**										
CEC	0.803**	0.548	-0.858**	-0.812**	-0.752*	0.189	-0.698*	-0.235	0.897***	-0.726*	0.975***									
Bs	0.415	0.753*	-0.563	-0.682*	-0.359	-0.187	-0.730*	-0.579	0.978***	-0.984***	0.928***	0.824**								
NP	0.277	0.132	-0.406	-0.532	-0.229	-0.174	-0.576	-0.529	0.368	-0.260	0.408	0.436	0.304							
AB	0.284	-0.258	-0.203	0.006	-0.357	0.475	-0.057	0.517	-0.435	0.584	-0.298	-0.149	-0.494	0.313						
NE	0.097	-0.057	-0.170	-0.173	-0.141	0.079	-0.449	-0.070	-0.149	0.212	-0.103	-0.048	-0.160	0.701*	0.771*					
GW	0.059	-0.032	0.139	0.460	-0.166	0.579	0.478	0.723*	-0.425	0.489	-0.366	-0.282	-0.455	-0.605	0.319	-0.253				
E/P	-0.253	-0.268	0.337	0.466	0.167	0.242	0.264	0.635	-0.613	0.520	-0.620	-0.610	-0.529	-0.592	0.400	0.142	0.460			
G/E	0.269	-0.332	-0.159	-0.035	-0.242	0.248	0.446	0.743*	-0.564	0.662	-0.447	-0.317	-0.608	-0.210	0.598	0.170	0.385	0.485		
GY	0.074	-0.280	-0.021	0.111	-0.137	0.299	0.049	0.456	-0.580	0.667	-0.490	-0.373	-0.609	0.264	0.954***	0.797*	0.273	0.487	0.637	

not significant
 * p ≤ 0.05
 ** p ≤ 0.01
 *** p ≤ 0.001

NP – number of plants
 AB – above-ground biomass
 NE – number of ears
 GW – average grain weight
 E/P – number of ears per plant
 G/E – number of grains per ear
 GY – grain yield