

## Supplementary information

### Tables

**Table S1.** Assignment of bands and/or peaks of the main vibration modes and functional groups of FTIR spectra according to Zhang et al.[7], Das et al. [47] and De Souza and Braganca [46].

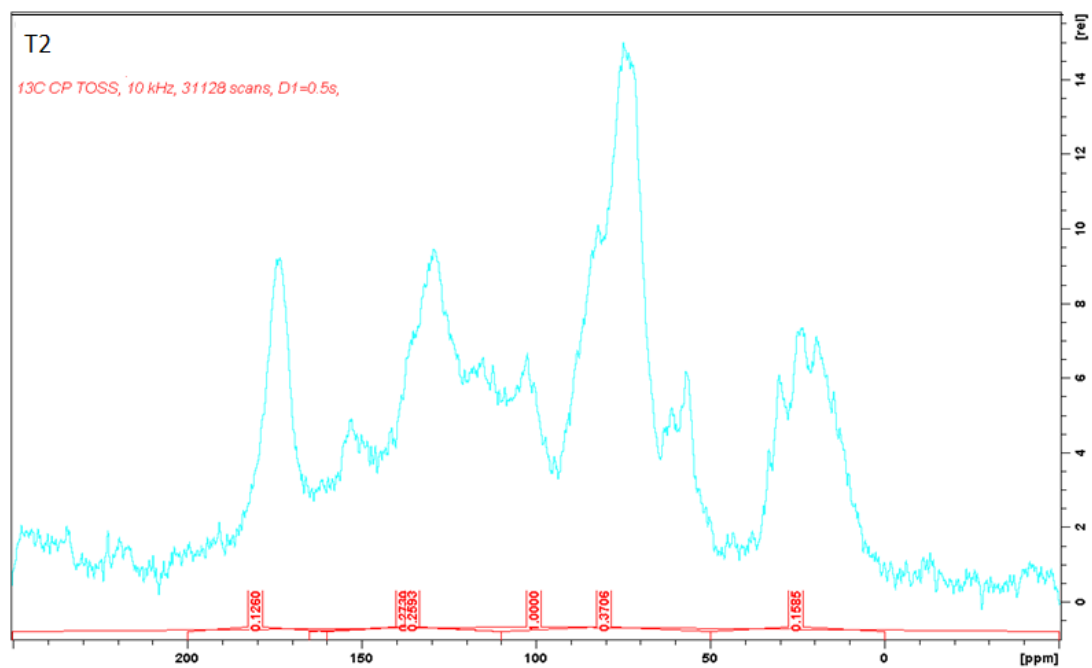
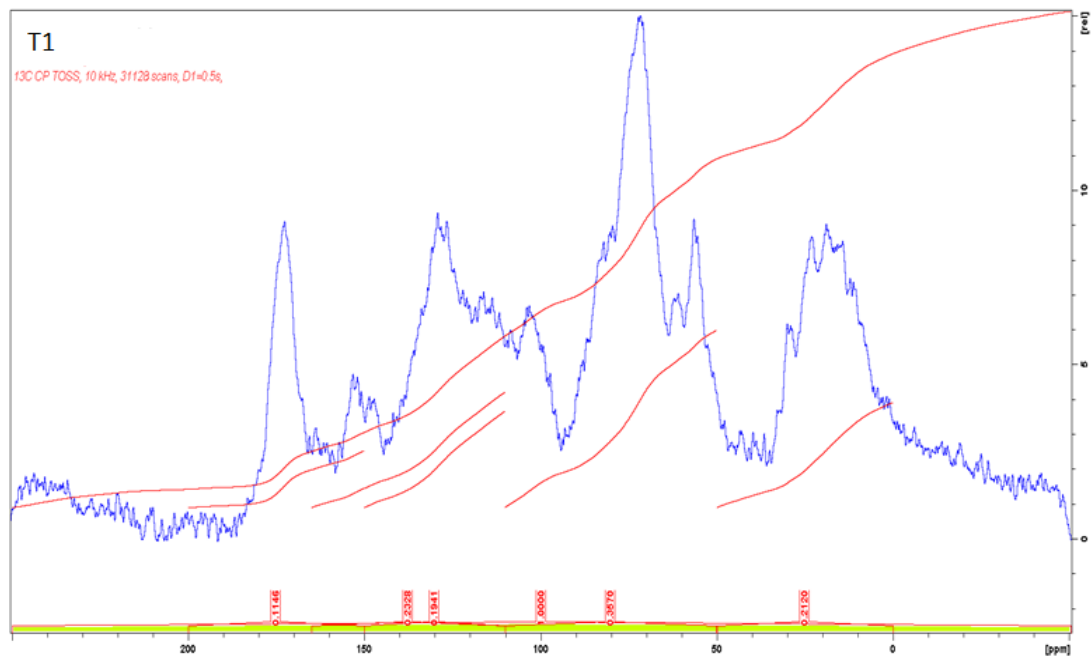
Absorption frequency (cm <sup>-1</sup> )	Vibration mode	Group
3600-3500	H-OH stretch	Hygroscopic water
3410-3385	O-H stretch	Phenolic compound, hydroxy group
2930-2920	C-H stretch	Aliphatic compound
1720	C = O stretch	Carboxyl, aldehyde, ketone
1650-1640	C = O stretch	Amino compound, carboxylate
1630-1600	C = C stretch	Aromatic ring, alkene
1570-1500	N-H and OH deformation, C = N stretch	Amino compounds and secondary amides
1515-1510	Aromatic C = C stretch	Lignin
1460-1440	C-H stretch	Aliphatic CH deformation
1420-1410	O-H OH deformation, C-O stretch	Aromatic oxide, phenol
1350-1384	C-H stretch	Symmetric deformation vibration of C-H of C-CH <sub>3</sub>
1320	C-N stretch	First, second aromatic amine
1240-1220	C-O stretch, OH deformation	Carboxyl
1080-1030	C-O stretch	Polysaccharides or aromatic ethers
880-750	C-H stretch	Aromatic CH out of plane deformation

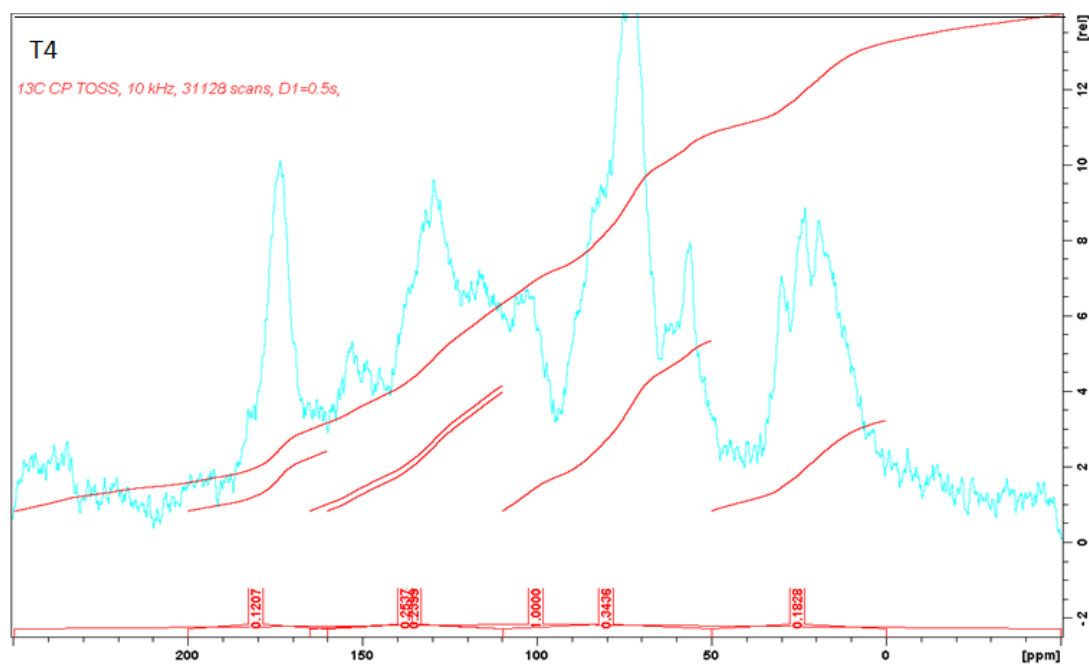
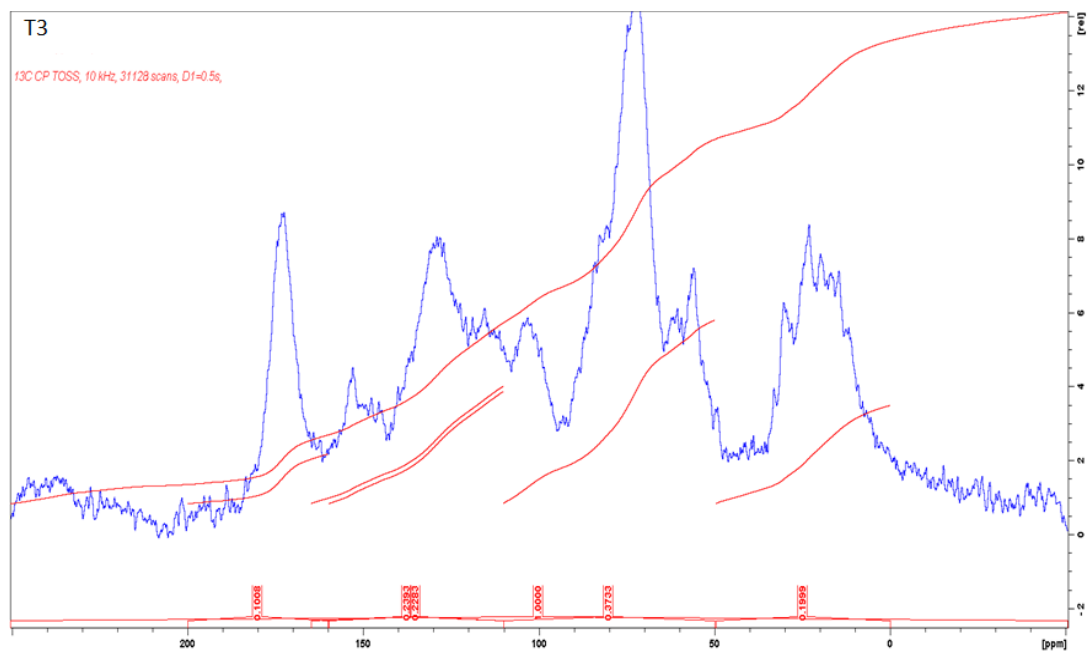
**Table S2** Effects of amendments on the relative intensities of the main absorption peaks of FTIR spectra of HAs

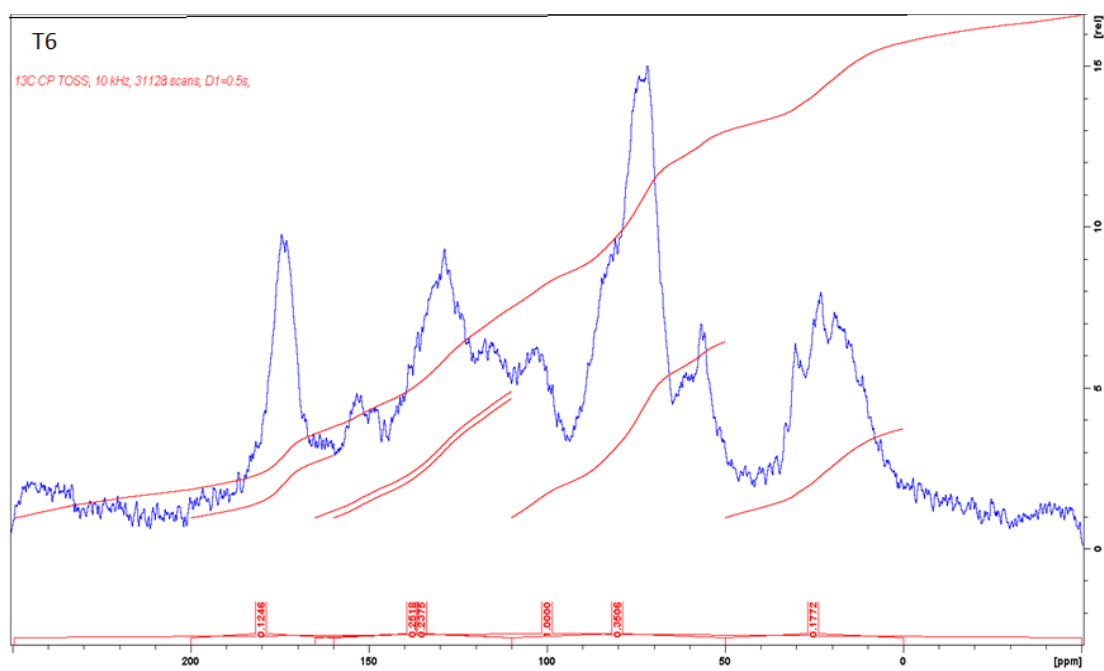
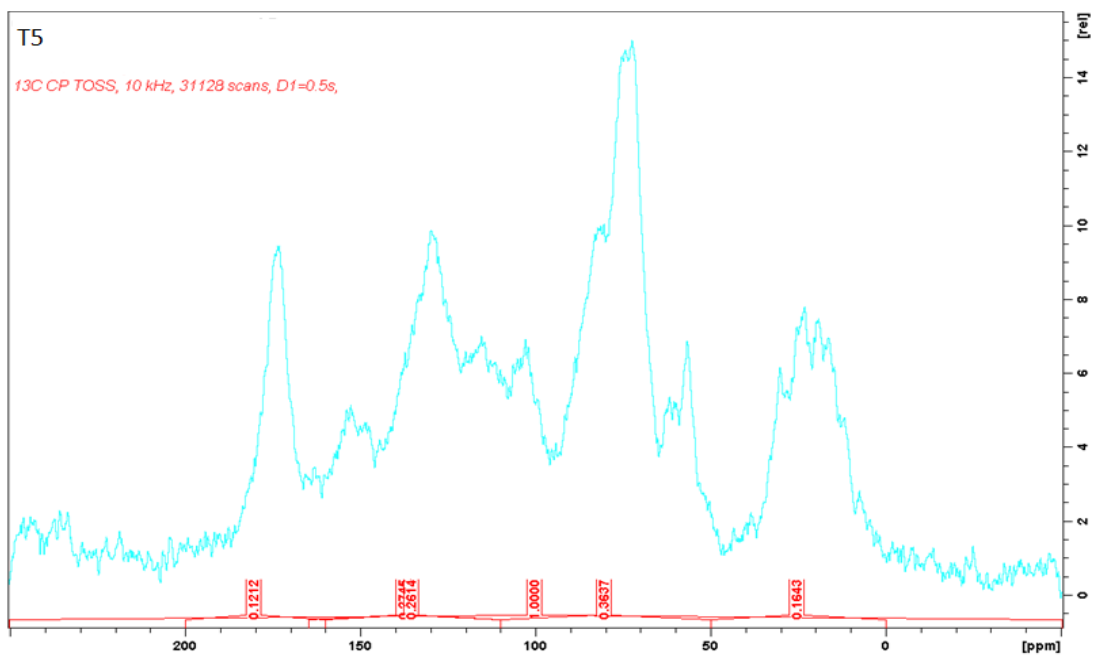
Treatment (Site)	2920 cm <sup>-1</sup>	2850 cm <sup>-1</sup>	1720 cm <sup>-1</sup>	1630 cm <sup>-1</sup>	I2920/I1720	I2920/I1620
T1 (S1)	0.21 ± 0.05	0.15 ± 0.06	0.80 ± 0.04	0.85 ± 0.13	0.27 ± 0.07	0.25 ± 0.03
T2 (S1)	0.17 ± 0.05	0.11 ± 0.05	0.74 ± 0.09	0.85 ± 0.10	0.24 ± 0.06	0.21 ± 0.05
T3 (S1)	0.20 ± 0.04	0.14 ± 0.06	0.76 ± 0.07	0.87 ± 0.07	0.27 ± 0.07	0.23 ± 0.03
T4 (S1)	0.24 ± 0.04	0.17 ± 0.03	0.82 ± 0.08	0.83 ± 0.14	0.29 ± 0.02	0.30 ± 0.11
T5 (S1)	0.25 ± 0.06	0.19 ± 0.04	0.83 ± 0.09	0.87 ± 0.11	0.30 ± 0.03	0.30 ± 0.11
T6 (S1)	0.27 ± 0.05	0.21 ± 0.05	0.83 ± 0.05	0.88 ± 0.11	0.33 ± 0.06	0.32 ± 0.05
T7 (S2)	0.18 ± 0.02	0.10 ± 0.00	0.72 ± 0.09	0.84 ± 0.02	0.25 ± 0.01	0.21 ± 0.02
T8 (S2)	0.27 ± 0.05	0.20 ± 0.04	0.82 ± 0.07	0.90 ± 0.00	0.33 ± 0.04	0.30 ± 0.05
T9 (S3)	0.21 ± 0.02	0.14 ± 0.01	0.80 ± 0.04	0.88 ± 0.07	0.26 ± 0.02	0.24 ± 0.05
T10 (S3)	0.27 ± 0.05	0.20 ± 0.04	0.82 ± 0.07	0.90 ± 0.00	0.33 ± 0.04	0.30 ± 0.05
T11 (S4)	0.19 ± 0.05	0.13 ± 0.05	0.85 ± 0.03	0.87 ± 0.11	0.22 ± 0.07	0.22 ± 0.05
T12 (S4)	0.20 ± 0.05	0.14 ± 0.05	0.90 ± 0.01	0.86 ± 0.12	0.22 ± 0.05	0.23 ± 0.03
LSD <sub>0.05</sub>	0.13	0.13	0.19	0.28	0.14	0.18

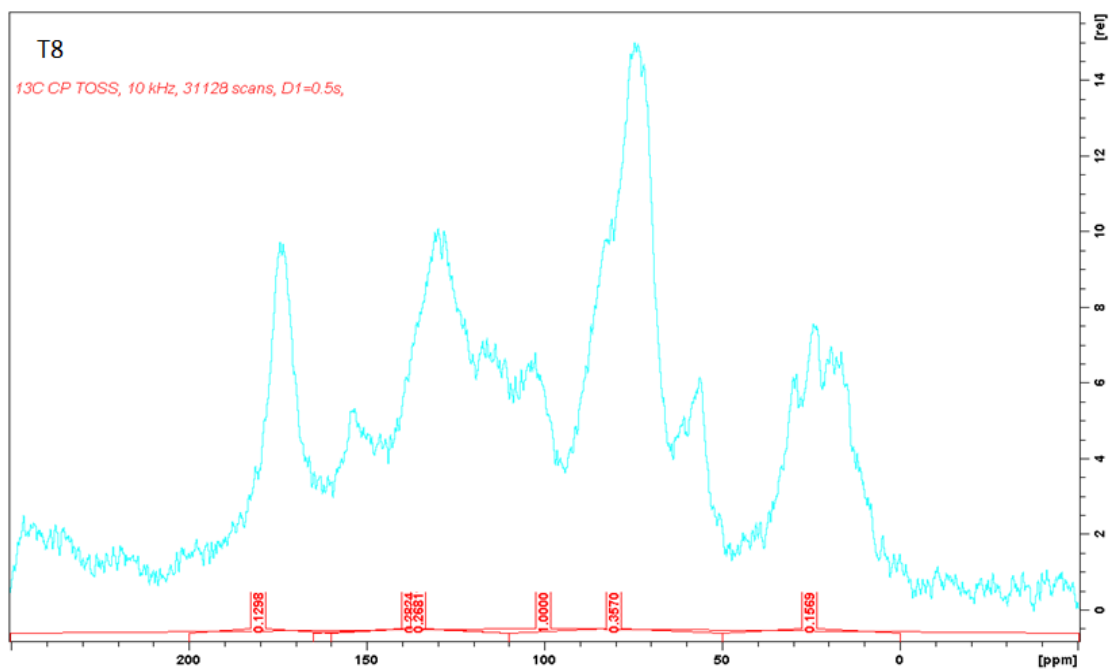
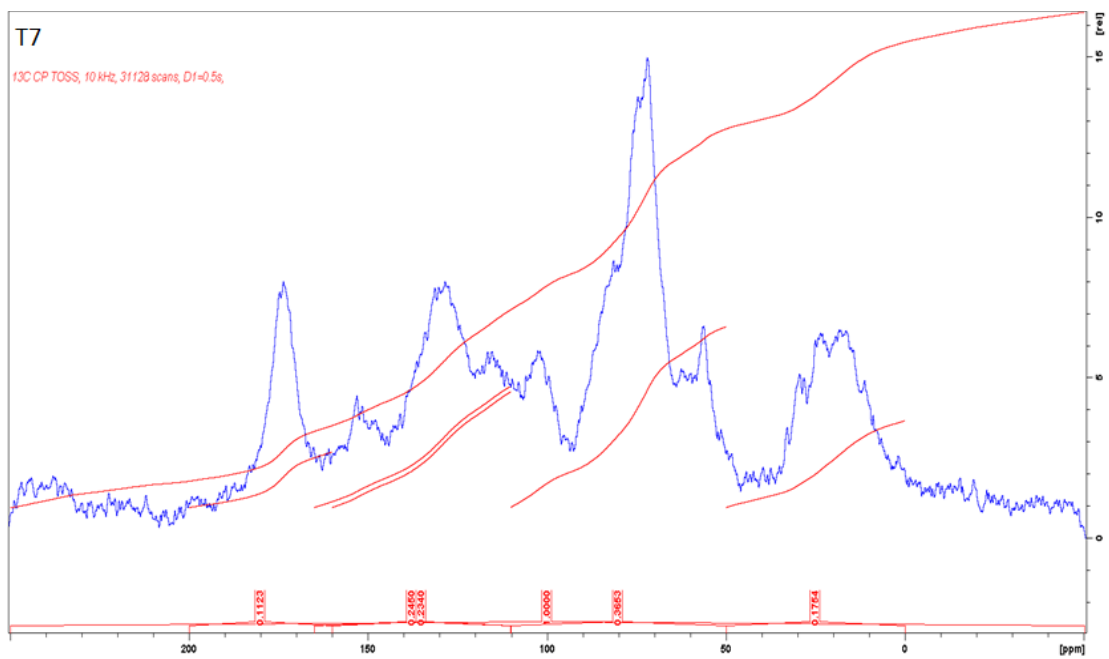
Values represent mean ± standard deviation; n = 3; n.s. – not significant; LSD – least significant difference; Tn – treatment number: T1 – farmyard manure (FYM, with field age of 0.5 years), T2 – brown coal waste (BCW, 0.5 years), T3 – biochar (BIO, 0.5 years), T4 – FYM (1.5 years), T5 – BCW (1.5 years), T6 – BIO (1.5 years), T7 – no amendment (8 years), T8 – BIO (8 years), T9 – no amendment (94 years), T10 – FYM + Ca (94 years), T11 – no amendment (116 years) and, T12 – FYM (116 years).

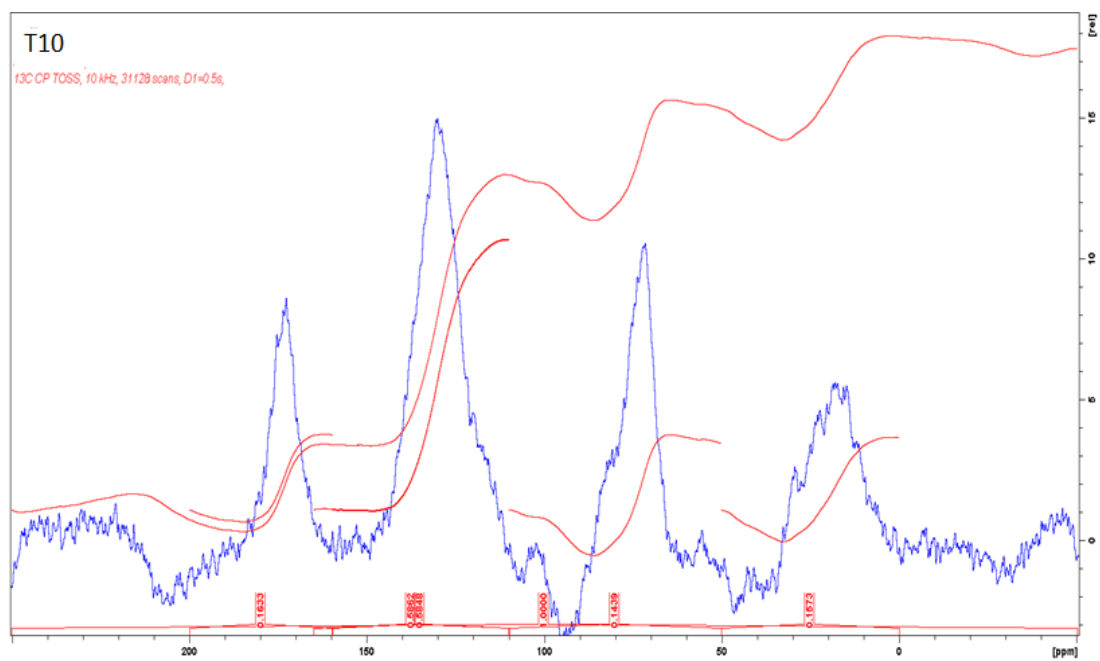
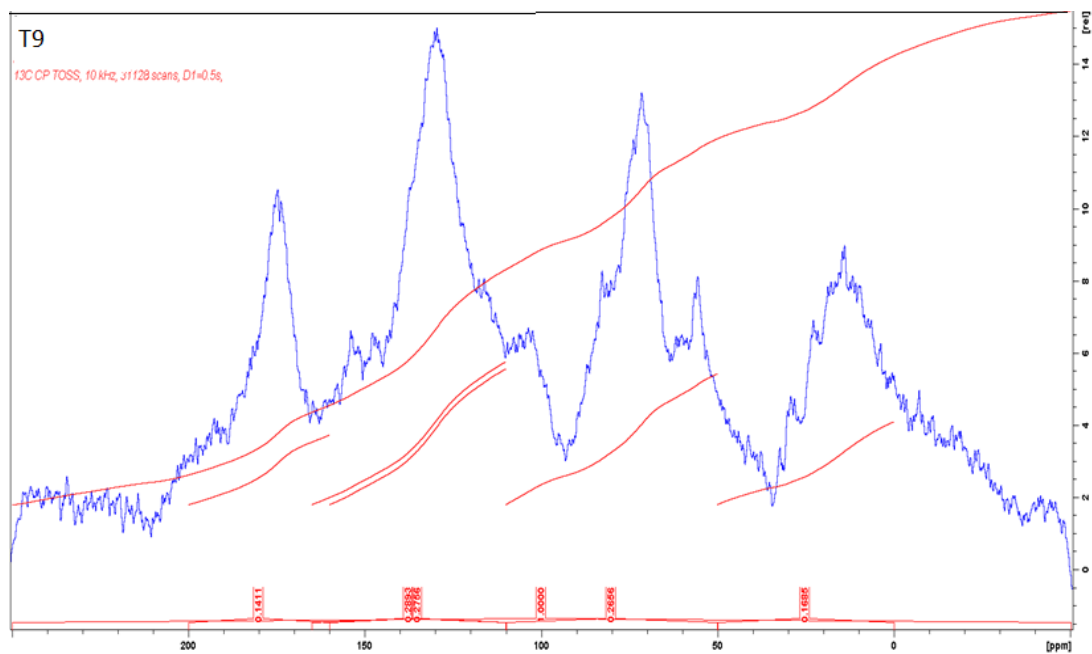
**Figure**

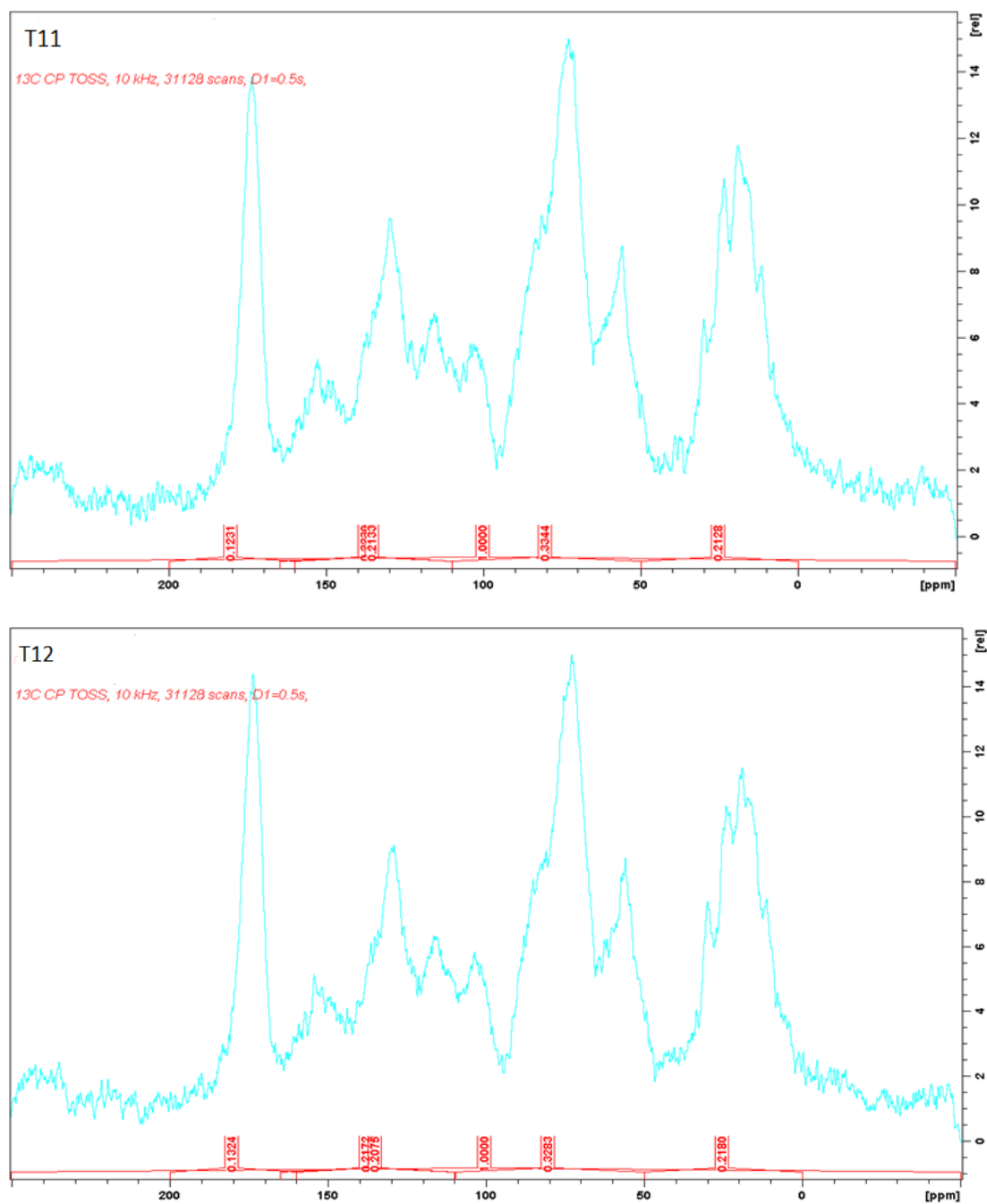












**Figure S1.** Solid-state cross polarisation magic angle spinning nuclear magnetic resonance (CP/MAS  $^{13}\text{C}$ -NMR) spectra of humic acids from soils under different organic treatments. Tn – treatment number: T1 – farmyard manure (FYM, with field age of 0.5 years), T2 – brown coal waste (BCW, 0.5 years), T3 – biochar (BIO, 0.5 years), T4 – FYM (1.5 years), T5 – BCW (1.5 years), T6 – BIO (1.5 years), T7 – no amendment (8 years), T8 – BIO (8 years), T9 – no amendment (94 years), T10 – FYM + Ca (94 years), T11 – no amendment (116 years) and, T12 – FYM (116 years).