

**Fig. 2S.**FT-IR spectra of the crop residues incorporated in the soil.

According to the spectra interpretation, the high and wide peak at 3350-3200 in all the plant residues denotes the presence of hydroxyl group (Alemdar and Sain, 2008; Shahbazi et al., 2017; Türker-Kaya and Huck, 2017). The higher absorbance for this compound was registered in the oilseed rape plant, followed by rye, and wheat straw with the lowest absorbance. Close to it, an asymmetric and symmetric stretch of aliphatic compounds are revealed at 2920 cm-1 and 2850 cm-1, respectively (Trinsoutrot et al., 2001; Türker-Kaya and Huck, 2017). The absorbance of these compounds increased in order wheat straw<oilseed rape<rye. The stretching at 1730 cm-1 and 1737 cm-1 is represented by C=O group of acetate esters (Pappas et al., 1998; Sain and Panthapulakkal, 2006; Shahbazi et al., 2017; Zanuttini et al., 1998). Rye plant residues had the highest absorbance at this peak and wheat straw the lowest. The peak at 1647 cm-1 for wheat straw shows the presence of water associated cellulose (Alemdar and Sain, 2008; Türker-Kaya and Huck, 2017; Xiao et al., 2001)

The high peak at 1630 cm-1 in rye residues denotes the existence of C=O stretch in the amide I and repeating at 1540 cm-1 as C-N stretching in amide II (Pappas et al., 1998; Séné et al., 1994; Trinsoutrot et al., 2001; Türker-Kaya and Huck, 2017). The high peak found at 1597 cm-1 in oilseed rape can be assigned to C=O stretch of the aromatic ring of lignin or COO- in hemicelluloses (Horikawa et al., 2019). Also, the aromatic ring stretch of lignin compound is highlighted by the 1508 cm-1 peak, which was found only in wheat straw (Türker-Kaya and Huck, 2017; Zaccheo et al., 2002; Zanuttini et al., 1998). The small peaks from 1454 cm-1, 1423 cm-1, 1370 cm-1, and 1320 cm-1 present in wheat straw, represents the deformation of C-H and O-H bending frequencies of polysaccharides (Alemdar and Sain, 2008; Rodrigues et al., 1998; Sain and Panthapulakkal, 2006; Séné et al., 1994). The peaks at 1404 cm-1 in oilseed rape are attributed to the same C-H deformation in cellulose and hemicellulose compounds (Stewart and Morrison, 1992). The peak at 1370 cm-1 present in rye signifies the deformation of C–H bend in cellulose and hemicellulose (Alemdar and Sain, 2008; Rodrigues et al., 1998). The lower absorbance at 1244 cm-1 in the rye and 1242 cm-1 in oilseed rape is associated with C-O stretch of polysaccharides (Rodrigues et al., 1998; Shahbazi et al., 2017). The absorbance at the peak 1157 cm-1 in wheat straw and rye presents the C-O-C vibrations in cellulose (Rodrigues et al., 1998; Xiao et al., 2001; Zaccheo et al., 2002). The highest at 1030 cm-1 is distinct for C-O band vibrations of cellulose, hemicellulose and lignin compounds (Rodrigues et al., 1998; Shahbazi et al., 2017; Zaccheo et al., 2002). The out of plane peak at 897 cm-1 has been observed in wheat straw and rye that is caused by C-H deformation in cellulose (Rodrigues et al., 1998; Shahbazi et al., 2017). Thus, wheat straw has a much higher concentration of lignin compounds and cellulose than other plant residues. The difference between rye and oilseed rape consists of a higher level of cellulose and aliphatic compounds and lower protein compounds of rye residues.