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Soil physical and X-ray computed tomographic measurements to investigate small-scale structural differences under strip tillage compared to mulch till and no-till

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In recent years there has been an increasing application of conservation tillage techniques where the soil is no longer turned, but only loosened or left completely untilled. Dead plant material remains on the soil surface, which provides environmental and economic benefits such as the conservation of water, preventing soil erosion and saving time during seedbed preparation. There is a variety of conservation tillage systems, e.g. mulch till, no-till and strip tillage, which is a special feature. In strip tillage, the seed bed is divided into a seed zone (strip-till within the seed row: STWS) and a soil management zone (strip-till between the seed row: STBS). However, each tillage application affects physical soil properties and processes.
Here, the combined application of classical soil mechanical and computed tomographic methods is used on a Chernozem (texture 0-30 cm: silt loam) to show small-scale structural differences under strip tillage (STWS, STBS) compared to no-till (NT) and mulch till (MT). In addition to the classical soil physical parameters dry bulk density and saturated conductivity (years: 2012, 2014, 2015) at soil depths 2-8 and 12-18 cm, stress-strain tests were carried out to map mechanical behavior. The stress-strain tests were performed for a load range from 5-550 kPa at 12-18 cm depth (year 2015). Mechanical precompression stress was determined on the stress-dry bulk density curves. Further, CT image cross sections and computed tomographic examinations (average pore size, porosity, connectivity, and anisotropy) were used from the same soil samples.
For STBS and NT, a significant increase in dry bulk density was observed over the course of time compared to STWS and MT, which was more pronounced at 2-8 cm than at 12-18 cm depth. Despite higher dry bulk density, STBS displayed higher saturated conductivity in contrast to STWS, which can be attributed to higher earthworm abundance. In strip tillage, structural differences were identified. Mechanical precompression stress was significantly higher for STBS (141 kPa) than STWS (38 kPa). In addition, the CT image cross sections and the computed tomographic parameters confirmed the mechanically more stable soil structure observed under STBS with a higher initial average pore size but lower porosity and connectivity values compared to STWS. The reason for this is the lack of tillage. On the other hand, tillage at STWS created a loosened, porous and connective substrate. For all variants, the increasing load application led to progressive homogenization processes of the soil structure. At the same time, as stress application increased in all variants, the increase in dry bulk density led to a decrease in average pore size, porosity, and connectivity, while anisotropy increased.
It was possible to confirm that strip tillage combines the advantages of no-till and a deeper conservation primary tillage, since on the one hand MT and STWS and on the other hand STBS and NT showed very similar soil structures. The computed tomographic parameters therefore provide valuable information about the impact of tillage on microscopic pore space attributes that improve our understanding about soil functional behavior at much larger scales.