Editorial for the Special Issue on ‘Opportunities and Challenges in No-Till Farming’

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This special issue was initiated after the 21st World Congress of Soil Science held in Rio de Janeiro in 2018 by inviting presenters (also open to all) from the session titled ‘Contribution of zero tillage (no-till) to sustainable use and management of soils (C.3.3.7)'. Zero tillage or NT is an important conservation tillage practice in which soil disturbance is kept to a minimum, and the soil is usually covered with 30–100% plant residues. Although it provides several advantages, the uptake of NT is not uniform across the world. Thus, this special issue aimed to publish the state of the art on NT and its influence on biogeochemical and greenhouse gas emissions, soil micro and macrofauna, soil physical and hydraulic properties and soil and crop management at different spatial and temporal scales.

The 16 accepted articles of this special volume can be broadly divided into two main groups. The first group consists of specific NT impacts on physical, chemical and biological properties of soils, and the second group focuses on combined assessments, i.e. the assessment of NT impacts in the combination with grazing, fertilization and cropping.

Specific NT impacts on physical, chemical and biological properties of soils

The specific NT impacts on physical, chemical and biological properties were studied by eight articles with the following emphases: (i) one paper highlighted the three pillars of NT systems and concentrated on helping farmers to implement good soil management systems; (ii) two studies were on soil biological properties affected by NT with the foci on earthworms and bacterial communities; (iii) two papers reported longer-term effects (> 10 years) on either soil biochemical properties and microbial community structure or carbon sequestration; and (iv) three studies examined the benefits of conservation agriculture (CA) compared with conventional agriculture.

(i) Farmers may often fail to adopt the principles and practices followed in NT. In order to tackle this problem, Nunes *et al.* focused on the three pillars of the NT system – minimum mechanical soil disturbance, permanent soil cover and plant diversity, and implemented a participatory quality index (PQI) in Brazil, which enabled the farmers to self-assess and monitor soil management in an NT area. The tool was trialled on 40 areas of farmland under different farm systems in the Paraná River Watershed. Overall, the authors reported that the NT system PQI was used to successfully evaluate soil management quality.

(ii) The earthworm abundance was studied by Demetrio *et al.* who presented the long-term NT impacts (30 years) on earthworm populations in Brazilian NT soils. The authors identified 33 different species of earthworm, and around 75% of the sites examined had 'moderate to poor' earthworm population densities. They found the earthworm populations were primarily dependent on the climatic zones within the country and soil management practices. A key conclusion is that soil management practices need improvement in many NT systems to increase earthworm populations. A soil biological focus was also investigated by Khan *et al.* who studied the effect of microwave heating (a means to control weeds) on bacterial communities in an Australian NT soil, a Red Mesotrophic-Haplic Dermosol (Australian soil classification). High temperature treatments caused irreversible damages to bacterial community richness, and only heat resistant bacterial taxa could survive. Notably, they found that such treatment did not produce a negative impact on the abundance of ammonia-oxidising bacteria and archaea.

(iii) Long-term effects (>10 years) on either soil biochemical properties and microbial community structure or carbon sequestration were studied by Sekaran *et al.* and Nicoloso *et al.* Based on a multi-locational experiment in the US, Sekaran *et al.* found both, long- and short-term impacts of NT on biogeochemical properties, and reported that NT significantly increased labile C and N in comparison to conventional tillage (CT) along with fungal biomass, and several soil enzyme activities, improving overall soil biological health. Since long-term monitoring in the field is essential for the evaluation of different tillage systems, Nicoloso *et al.* utilised two long term experiments from Brazil (28 years) and the USA (30 years) to model (DSSAT-CENTURY) the long-term impacts on soil organic carbon (SOC). They found that NT under moderate C/N inputs recovered topsoil SOC, but subsurface losses offset SOC accumulation. Overall, NT complemented with best management practices including crop rotation and organic C inputs was effective in raising the SOC stock in NT soils.

(iv) Three studies focused on comparisons between CA and conventional agriculture. Camarotto *et al.* compared SOC changes under CA and CT for six years in Italy, and CA was found to enhance SOC stratification without increasing the SOC in the soil. Piccoli *et al.* employed geophysical assessment to examine the effect of CA and conventional agriculture on soil physical properties in Italy. Soil texture played an important role in deciding the effect of CA; they found that loamy soils low in SOC and clay contents were more vulnerable to surface compaction in comparison to the silty loam soils. Moreover, they noted that physical conditions of silty soils did not improve or deteriorate under CA. Mondal *et al.* presented their findings on the short-term (5 years) impact of CA practices, including NT on physical conditions of an Entisol (USDA soil taxonomy) from Indo-Gangetic plains of Bihar, India. They showed that CA increased macroaggregates and associated organic carbon within them, by increasing the C stock in CA systems in comparison to CT soils.

Assessment of NT impacts in combination with grazing, fertilization and cropping

The assessment of NT impacts in combination with different management practices were studied by eight articles with focussed on grazing, fertilization and cropping: (i) three studies investigated the combined effects of NT and grazing; (ii) three papers focused on the combination of NT with liquid manure, residue retention or phosphogypsum application in combination with additional treatments; and (iii) two studies investigated the effects of NT in combination with different cropping systems.

(i) All three studies which investigated the combined effects of NT and grazing were carried out at Brazilian sites. Deiss *et al.* examined the impact of moderate grazing on NT soils (Oxisols and Ultisols, USDA soil taxonomy) with cover crops, and found no significant impact on the presence of animals on agroecosystem productivity in three long-term experiments (7, 10, and 12 years). In another long-term experiment (9 years), Ramalho *et al.* also found that grazing did not compromise SOC gains under NT on a Ferralsol (Food and Agriculture Organization (FAO) soil classification). Ribeiro *et al*. carried out an on-farm assessment of net global warming potential (GWP) in NT integrated crop-livestock systems on a Ferralsol, and reported that moderate grazing was optimal for reducing GWP due to the SOC accumulation in comparison to no, light or intensive grazing options.

(ii) The studies on NT in combination with manure, residue retention or phosphogypsum applications were carried out at Brazilian and Chinese sites. Cavalcante *et al.* reported for a 10- year crop rotation system on a Brazilian Ferralsol that the application of dairy liquid manure (0, 60, 120 and 180 m^3 ha^{-1} $year^{-1}$) in NT soils increased C and N stocks up to 17 and 27% in the top 10 cm of the soil profile. Soil physical conditions were improved, and were related to organic matter changes. In a 4-year study on a Cambisol (FAO soil classification) in northern China, Yin *et al.* examined different water conservation strategies, and found that NT with residue retention and plastic mulching increased water use efficiency and maize yield in cold semi-arid regions of the country. To mitigate compaction in NT soils of Brazil, Pott *et al.* reported for an Oxisol that mechanical chiselling, polyculture cover crops, phosphogypsum and combination of these methods were useful in managing compaction and maximising soybean yields.

(iii) NT in combination with cropping was also studied at Brazilian and Chinese sites. Using a long-term experimental trial (32 years), Pires *et al.* highlighted for a Brazilian Oxisol that NT when combined with crop rotations increased soil enzymatic activities and individual phospholipid fatty acid groups. By returning the residues, clay size fraction showed the most substantial increase in SOC, as demonstrated by Zhang *et al.* based on maize and maize-soybean systems under NT and CT for a Chinese Mollisol (USDA soil taxonomy). They also found that biodegradability of the SOC was driven by the cropping system, not the tillage.

We would like to acknowledge the great support by the former Editor-in-Chief Professor Margaret Oliver, the current Editor-in-Chief Professor Jenni Dungait, and the EJSS publication team in compiling this special issue. Finally, we wish to thank the contributing authors, and offer our sincere gratitude to all the reviewers, without whom this special issue could not have been completed.

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