Conservation tillage and N fertilization affect soil aggregate distribution, carbon storage and enzymatic activities

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Abstract

Conservation agriculture is globally recommended for increasing carbon (C) stock in soil and reducing greenhouse gases emissions by modifying soil physical, chemical and biological processes. In the present study, soil aggregate fractions, soil organic C (SOC) and soil enzymatic activities in bulk soil and microaggregates within macroaggregates (mM) were measured in a long-term field experiment comparing conventional tillage (CT) and minimum tillage (MT) and N fertilizer to the rotation bread wheat (*Triticum aestivum* L.) – soybean (*Glicine max* L. Merr.). Under MT, a higher proportion of free microaggregates and a lower proportion of silt and clay was recorded compared to conventional tillage, suggesting a greater potential to form macroaggregates, despite their proportion was not modified by tillage. However, when macroaggregates were further fractionated, MT resulted in higher proportion of microaggregates. In bulk soil and in mM, all soil enzymatic activities were higher under MT than CT. Conversely, SOC in bulk soil was not modified by tillage, but was higher under MT in mM. These results demonstrate the crucial role of mM for C sequestration under reduced tillage. Thus, this fraction is proposed as an effective diagnostic tool to assess variations in carbon storage induced by agricultural practices.

Slide 1

Good afternoon, I am Gaia Piazza, PhD student in Agrobiosciences programme here at the SSSUP. Today my talk focuses on the effect of conservation tillage and N fertilization on soil aggregate distribution, C storage and enzymatic activities

Slide 2

In conservation agriculture, minimum or no disturbance of soil, soil coverage and crop rotation are widely considered as good practices that allow an increase of soil C stock and a reduced emission of greenhouse gases by modifying physical, chemical and biological properties and processes.

Slides 3, 4

Analysing the effect of tillage on changes in soil organic carbon content under no-tillage compared to conventional tillage, meta-analyses carried out by Luo and Powlson showed
an accumulation of organic C in the layer 0–10 cm, and a decrease at 20-40 cm depth

Slides 5, 6

Regarding N fertilization, De Sanctis showed ina long-term field experiment that the use of an adequate rate of N fertilizer consistently increase SOC accumulation in NT system.
In addition Russel demostrated that an increase of N fertilizer can also increase SOC accumulation depending on crop rotation

Slides 7, 8

Moreover, it is interesting to note that soils with an increased availability of mineral N promoted the production of extracellular enzymes involved in the C cycle,
as showed in this meta-analysis that considered the long-term application of N fertilizers.

Slide 9

Latest studies showed that the physical protection of SOM and not his chemical composition is the main driver regulating C storage in soil. The conceptual model for aggregate hierarchy described by tisdall and oades illustrate how primary mineral particles are bound together with bacterial, fungal, and plant debris into microaggregates. These microaggregates, in turn, are bound together into macroaggregates by transient and temporary binding agents. Carbon concentration increases with the increase of the size class of aggregates and younger and more labile OM is contained in macroaggregates than in microaggregates.

Slide 10

Within macroaggregates there is an important component, the mM, where SOC is protected in the long-term and his stabilization depends on macroaggregates turnover

Slide 11

The previous studies are mostly based on results of experiments performed on clay soils. So, it is interesting to know how long-term conservation management practices (reduced tillage systems and N fertilizer rates) could affect soil carbon and microbial functionality in sandy-loam soils? For this purpose I analysed the soil aggregate distribution and the SOC dinamycs as well as enzymatic activities on both bulk soil and mM

Slide 12
To this aim, I utilised a long-term tillage and N fertilization experiment comparing two tillage systems and two levels of N fertilization to wheat in a soybean-bread wheat rotation

Slide 13
For the physical fractioning of aggregates, the wet sieving method was applied, obtaining 4 aggregates classes. Then, a device was drawn, built and utilized to isolate microaggregates within macroaggregates.

Slides 14, 15
Going to the results, tillage and N fertilization similarly affected aggregates distribution at both soil depth and a higher proportion of free microaggregates was recorded under MT compared to CT, suggesting a greater potential to form macroaggregates, despite this fraction was not modified either by tillage or by N fertilization residual effect.
When small macroaggregates where further fractionated only at 15-30 cm their proportion was significantly affected by tillage.

Slides 16, 17
In bulk soil, although SOC content did not statistically change comparing MT to CT, there was a consistent trend of SOC decrease in CT respect to MT.
By contrast, there was a strong and constant increase in all the enzymes related to C-cycle under MT compared to CT. This can be due either to a different quality of organic matter in terms of recalcitrant compounds or to the reduced disturbance induced by minimum tillage on the activities of soil microbes

Slides 18, 19
Looking at the SOC in mM, there was a trend of increased SOC content in MT due to N fertilization residual effect and a decrease in the CT with N fertilizer rate at 0-15 cm. Interestingly, N fertilization residual effect strongly increased SOC content in MT at 15-30 cm depth.
What about enzymes involved in C-cycle in mM? Only at the top layer, there was a significant decrease in MT system with N fertilization and an increase due to N fertilization in CT. This different effect might come from the higher availability of organic matter in well-aerated and less structured soils (as in CT systems), enhancing decomposition processes by microbial activity. On the other hand, MT reduced the availability of C substrates in the mM, with the consequent immobilization of microbial processes that lead to the SOC increase found in this fraction.

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In conclusion…..