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How tillage systems and cover crops affect soil penetration resistance

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Penetration resistance (PR) is one of the most informative parameters to evaluate soil structure, being related to soil texture, compaction, and water content. PR tests are cheaper and more conservative than bulk density analyses, while potentially they can explore a deeper soil layer. On the other side PR is more sensitive to water content variation. Within this context the aim of this study is to evaluate the effects of different tillage systems and soil covers on soil strength, using PR as an indicator.

In this study, 288 PR tests were performed in the 0-80 cm profile, in an 18-plot field experiment considering three levels of tillage (conventional “CT”, minimum “MT” and no-tillage “NT”) combined with three soil covering during winter (bare soil “BS”, tillage radish “TR” and winter wheat “WW”) with two replicates. The experiment, located in northern Italy, had a homogeneous soil texture (silty loam) and it was sampled in late winter, when the gravimetric water content was equal in all the plot and along the soil profile ($0.34 \text{ m}^3\text{m}^{-3}$ on average, close to field capacity). A total of 16 tests were taken in each plot with a hand-pushed digital cone penetrometer with a base area of 2 cm^2 and an apex angle of 30° .

Average PR tended to increase with soil depth observing a growth from 0.25 to 1.53 MPa in the 0-15 cm layer, constant values (1.30 MPa on average) in the following 20 cm-layer, increased value up to an average of 2.87 MPa in 35-55 cm layer and reduced value (2.63 MPa on average) in the deepest layer (60-80 cm).

Considering the tilled layer (0-30 cm), PR was significantly affected by both tillage and soil covering being lower in CT (1.00 MPa) than MT and NT (1.03 MPa on average) and being lower with WW (0.98 MPa) than BS and TR (1.04 MPa on average). Similar results were registered also looking at the whole soil profile with tillage treatments ranked as follows: $\text{CT} < \text{NT} < \text{MT}$, while for the cover crops WW and BS (1.81 MPa on average) resulted significantly lower than TR (1.93 MPa). The 2 MPa threshold, considered a critical value for plant growth, was exceeded in the 41% of measured points in TR, 38% in WW and in 35% in BS. Most of exceeding values were collected below the tilled layer (below 30 cm depth).

These preliminary results might suggest the need to carefully monitor the soil strength during the transition period between conventional to conservation agriculture. Indeed, it seemed that tillage radish unexpectedly increased the soil PR, that instead could be mitigated in the top layer with

WW. Nevertheless, crop yield was not affected by the type of winter covering, despite the high PR observed in the 30-80 cm layer with TR. This could confirm that an important cover crop function is the creation of root channels, defined as "bio-macropores", that can be used as preferential path by subsequent crop roots even in a strongly compacted soil.