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Alternatives to Glyphosate in conservation agriculture: effects on carbon sequestration in a field experiment in northern Italy

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Conservative Agriculture (CA) practices are recognized to enhance soil organic carbon stock and in turn to mitigate the effect of climate change. One of the CA principles is to integrate cover crops (CC) into the cropping systems. The termination of CC before the cash crop sowing and the weeds control are the most critical aspects to manage in the CA. The technique currently adopted by farmers for the termination of CC implies the use of Glyphosate. However, the European Commission is currently discussing the possibility of banning the use of this herbicide due to the negative effects on human health and the agro-environment. The disk harrow (DH) or the roller-crimper (RC) can be adopted in CA as an alternative to the use of Glyphosate for the devitalization of CC, their incorporation into the soil (in the case of the disk harrow), and the reduction of weed pressure on the subsequent cash crop.

From November 2017 to October 2019, soil organic carbon (SOC, g kg⁻¹) and crop biomass production were observed in a 2-year field experiment located in Lodi (northern Italy), in which minimum tillage (MT) has been applied for the last 5 years. The soil was loamy and SOC was 16.2 g kg⁻¹ at the beginning of the experiment. The winter CC was barley (from November to May) and the cash crop was soybean (from June to October). The experiment consisted in three treatments replied for two consecutive years in a randomized block design: Glyphosate spray + DH + sowing + hoeing (MT-GLY); DH + sowing + hoeing (MT-ORG); RC + sod seeding (NT-ORG).

At the end of 2019, SOC resulted in a higher increase in MT-GLY (+15%) and in MT-ORG (+14%) than in NT-ORG (+6%; p<0.01). This was due to the fact that CC litter in NT-ORG was not in direct contact with soil particles and the process of immobilization was lower than in the other treatments.

Moreover, the increase in SOC resulted positively correlated to the CC biomass (2018+2019), which was significantly lower in NT-ORG. In particular, no differences of soybean and CC between the three treatments were observed at the end of 2018, but MT-GLY resulted in significantly higher CC and soybean biomass at the end of the second year (+32%, p<0.01). MT-GLY allows to stock more carbon via photosynthesis that in turn results in higher SOC content.

However, if we consider the tractor fuel consumption (for Glyphosate spray, DH, RC, hoeing), along with the biomass production, the carbon sequestration did not vary between the three treatments.

Further studies are needed for the definition of optimized field management practices to reduce the passage of machinery while increasing crop production and SOC.