Agronomic aspects of cover crops termination with roller crimper

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Introduction

Cover crops (CCs) are used in conservation systems to deliver a number of ecosystem services, including soil erosion prevention, water infiltration and storage, reduced nutrient losses, increased organic matter content and competitionon with weeds (Blanco-Canqui et al., 2015; Mazzoncini et al., 2011). The CCs can be terminated prior to planting the cash crop and residues can remain on the soil surface and act as a dead mulch that suppresses the weeds, also protecting the soil from rapid desiccation and keeping the soil moisture at good levels for cash crop seed germination or plant establishment (Bavougian et al., 2019). A method to terminate CCs in organic no-till systems is to use roller crimpers (RCs) (Frasconi et al., 2019; Kornecki et al., 2009). There is a higher termination rate when RCs are used at least from the flowering stage of legume CCs and the anthesis of grass CCs (Miville and Leroux, 2018). A delayed termination date of winter grown CCs may result in postponed sowing dates of the spring cash crop, likely resulting in loss of yield (Teasdale et al., 2012). Thus, a wider adoption of RCs would likely pass through identifying solutions to improve their effectiveness even at earlier phenological stages of CCs, e.g. by using heavy roller.

Materials and Methods

The experiment was conducted in the growing season 2018-2019 at "De Angeli" farm in Cenaia, Pisa (43°34'40''N 10°32'02''E, 27 m a.s.l.) on two neighbouring fields. The soil was a sandy-loam with 1 g 100 g^{-1} of organic matter. The experimental factors were: (i) two CCs species, rye (*Secale cereale* L.) and hairy vetch (*Vicia villosa* Roth.); (ii) three termination dates, i.e. end of March (stem elongation in rye/full vegetative stage in vetch), half April (earing in rye/beginning of flowering in vetch) and half May (milky ripening in rye, 70% flowering in vetch); (iii) one or two passes (the second 7 days after the first) of the Dondi RT 300 Cut Roller (Dondi S.p.A., Bastia Umbra), a roller weighting 1.9 t when empty and normally used as no PTO-propelled crusher. Each field was divided in six strips, 6 m wide and 200 m length, and each strip was divided in 5 plots, 6 m wide and 40 m length, which were the pseudo-replicates. The CCs were sown on ploughed soil in September 2018, at 40 and 150 kg seeds ha^{-1}, for hairy vetch and rye respectively. CC and weed biomass samplings were carried out before and after each first rolling pass, in two replicates per plot of 0.5 m^2. The CC biomass collected after the rolling pass was subdivided in cut and crimped plants to assess the effect of the roller. Termination of CCs was assessed at each date by image analysis of the greenness of the dead mulch over time. On two fixed assay areas of 1 m^2 per plot we collected pictures the day of termination (T0) and then 1, 2, 3, 6, 9, 12 days after termination (DAT) (T1, T2, T3, T6, T9, T12).

Results

The above ground dry matter (DM) of rye before the rolling pass resulted significantly higher than that of the vetch (11.44 vs 5.11 t ha^{-1}, respectively). For rye, the later the date, the higher the biomass, that reached 13.95 t ha^{-1} of DM at milky ripening. For vetch, the highest DM was observed at beginning of flowering, instead. Weed biomass was negatively correlated with CC biomass in vetch, whereas for rye we did not observe any relation. The percentage of crimped CC biomass showed a significantly higher value for rye (97%) than vetch (73%), whereas the opposite was observed for cut biomass (3% vs 27% respectively for rye and vetch). Interestingly, the second pass of the roller succeeded to significantly reduce the time needed to achieve at least 90% of desiccated biomass for both the CC species. This happened also at the earliest termination date, revealing the potential of the roller to anticipate CC termination date.

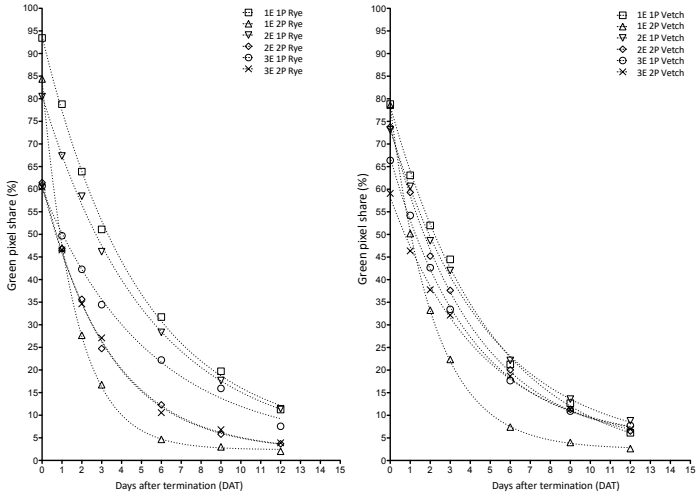

Figure 1. Temporal trend of the % of green pixels in the pictures of CC biomass collected at the three termination dates (1E, 2E, 3E) after 1 (1P) or 2 (2P) passes of the roller on rye (left) and vetch (right)

For vetch, which produced about half the biomass compared to the rye, the double passage of the roller was crucial only in the first period, allowing to cut down in about 6 days the time to obtain just 5% of plants still green. Overall, the vetch was easier to terminate than rye which, due to the enormous amount of biomass produced, reduced the pressure exerted by the roller on plants, ensuring at least double the regrowth compared to the vetch.

Conclusions

The use of the RC showed a high efficacy already at the earliest date, i.e. at full vegetative stage of CCs, with two rolling passes. Overall, the need to increase the number of roller tests on different combinations of soil climate, CC and operating parameters is reiterated, as well as suggest further tests to improve its effectiveness for the early management of particularly "resistant" and very productive CCs in terms of biomass, such as rye.

Literature

Bavougian C.M. et al. 2019. Cover crop species and termination method effects on organic maize and soybean. Biol. Agric. Hort, 35: 1-20.
Blanco-Canqui H. et al. 2015. Cover Crops and Ecosystem Services: Insights from Studies in Temperate Soils. Agron. J, 107: 2449–2474.
Frasconi C. et al. 2019. Combining roller crimpers and flaming for the termination of cover crops in herbicide-free no-till cropping systems. PLoS ONE, 14: e0211573.
Kornecki T.S. et al. 2009. New roller crimper concepts for mechanical termination of cover crops in conservation agriculture. Ren. Agr. and Food Syst, 24: 165–173.
Mazzoncini M. et al. 2011. Long-term effect of tillage, nitrogen fertilization and cover crops on soil organic carbon and total nitrogen content. Soil Till. Res, 114: 165–174.
Miville D. and Leroux G.D. 2018. Rolled winter rye–hairy vetch cover crops for weed control in no-till Pumpkin. Weed Tech., 32: 251–259.
Teasdale J.R. et al. 2012. Reduced-tillage organic corn production in a hairy vetch cover crop. Agron J, 104: 621–628.