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RESPONSE TO EDITOR

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The importance and requirement of belowground carbon inputs for robust estimation of soil organic carbon dynamics: Reply to Keel et al. (2017)

In a recent paper, we assessed the legacy data reported by Skjemstad and Spouncer (2003) and found that the amount of aboveground carbon (C) input (i.e. crop residues) in Australian cropping systems was the most important factor affecting soil C change among all the assessed drivers including the quantity and quality of C inputs, climate and soil properties (Luo, Feng, Luo, Baldock, & Wang, 2017). Keel, Hirte, Abiven, Wüst-Galley, and Leifeld (2017) argued that the C input data used in our study “may have led to important biases and critical omissions”, due to: (i) ignorance of belowground C inputs from roots/rhizodeposition and (ii) use of a constant harvest index (HI) for crops. They contended that “belowground C inputs can contribute as much as 90% to total carbon inputs in agroecosystems” by citing Kätterer, Bolinder, Andrén, Kirchmann, and Menichetti (2011) and Bolinder, Janzen, Gregorich, Angers, and VandenBygaart (2007), and that C partitioning above- and belowground also responds to fertilisation and management. For these reasons, Keel et al. (2017) concluded that our results on the driver importance may be biased.

First, the relative contribution of above and belowground crop C to total C input into soil depends on how crop stubble is managed. The higher (up to 90%) contribution by belowground crop C cited by Keel et al. (2017) was only true when crop stubble was removed. Under stubble retention, particularly stubble incorporation, the contribution of aboveground crop C is much higher. Synthesising available data, Pausch and Kuzyakov (2017) indicated that crops (mainly cereals) on average allocate 21% of the photosynthesised C to belowground and 45% to shoot biomass. Assuming a HI of 0.4, 27% of the photosynthesised C remains in crop shoots, which is alone greater than the C allocated to belowground if retained. Second, gross rhizodeposition on average accounts for 7% of total assimilated C and more than half (4%) loses as microbial respiration, with only 3% as net rhizodeposition (Pausch & Kuzyakov, 2017). Additionally, rhizodeposition may result in stimulation of soil C decomposition (i.e. the so-called rhizosphere priming effect) (Cheng, Johnson, & Fu, 2003), offsetting its positive effect on SOC accumulation. Third, below and aboveground C partitioning of crops are highly correlated, albeit root: shoot ratios may vary with cultivar and environmental conditions. In Australia, the rate of HI increase due to breeding is about 0.015 per decade (Unkovich, Baldock, & Forbes, 2010), corresponding to an increase of ~0.039 in the average 26 years of data we used, even less if other factors are considered (Zhao et al., 2014). The assumption of a constant HI would have minimum impact on the estimation of residue amount.

We agree with Keel et al. (2017) that it is important to understand the contribution of belowground C inputs and that variations in HI and management practices would change the crop root:shoot ratio. However, we do not think that our method has led to biases in the estimation of the driver importance. Further considering the impact of belowground C inputs, HI and management changes would not significantly change our results due to their much smaller impact as analysed above.

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