SOIL Discuss.,
doi:10.5194/soil-2017-5-AC3, 2017

SOIL Discussions

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Interactive comment

Interactive comment on "A deeper look at the relationship between root carbon pools and the vertical distribution of the soil carbon pool" *by* Ranae Dietzel et al.

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Received and published: 19 May 2017

Anonymous Referee #2
Received and published: 17 April 2017

Dietzel et al. report on a root study conducted at a field experiment where continuous corn is compared to reconstructed fertilized and unfertilized prairie stands. They have measured: 1) root profiles to depth of 1 m at the end of the growth season for six consecutive years, 2) root production (by regrowth cores) for 2 growing seasons to 30 cm depth, 3) root and soil C and N concentrations to 1 m depth. Extracting root for multiple growing seasons, multiple soils layers and multiple replicated treatments is by no mean easy, and the soil science community can certainly benefit from such precious

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data. The authors report interesting findings: 1) the C/N ratio of root material increases with depth, which has potential implications for soil C storage, 2) the maize root profile is more uniform with depth than that of prairie species (confirmative), 3) fertilization of the reconstructed prairie greatly decreases root biomass.

However, I have some significant concerns with the study:

1) The continuous accumulation of maize roots throughout the 6-year period is quite troubling (Fig A3). The authors provide one reference (Dupont 2014) stating that intact prairie root (not maize) can be found in soil several years after cultivation. However, they ignore the substantial literature on maize roots that clearly indicates that maize roots decompose rapidly in soils, starting with the classical study of Mengel and Barber in 1974 (Agron. J. 66: 341-344) and several studies that have followed. Actually, Mengel and Barber (1974) state that root length and fresh weight decrease rapidly after maize has reached the reproductive stage. Here, Dietzel et al. themselves state in the abstract about maize roots that they are "non-structural-tissue dominated root C pool with fast turnover". They also indicate that the site was apparently under maize soybean rotation prior to starting the experiment, so why was there no accumulated maize root biomass at the start of the experiment (if the root accumulation theory is correct)? Unfortunately, in the present study the roots were not sampled at the same time each year (from early October to early November), and the accumulation of maize roots the last two years also corresponds to the 2 earliest sampling. A possible explanation is that the roots actually decomposed quickly in the field and that by sampling a month earlier by the end of the six-year period a greater number of non-decomposed roots were retrieved. Effects of inter-annual climatic variability on root growth is another potentially contributing effect. There are three implications from this: 1) apparent maize-root accumulation in the field over 6 years is probably an artefact, 2) the pool and rate modelling of Fig 3 and 4 is not justified (it did not bring much to the paper anyway), 3) the paper should have included a

much more throughout review of the literature about maize-root dynamics in field soils.

Thank you very much for bringing this to our attention. The possibility of such as artifact led us to additional analysis of our data. During this analysis, we found that the dates included in the methods section were not correct. We are very sorry for this mistake. Please find below Fig. 1 that illustrates that time of sampling was most likely not a contributing factor in the accumulation of root mass at any depth.

You bring up some other useful points here, thank you. We can certainly include more papers on the decomposition of maize roots. Our values for maize biomass taken after maize harvest are typically 10 percent of maize root values taken at maturity. This is in line with studies that have found that maize roots decompose rapidly. However, decomposition rate is an exponential function, with rapid decomposition occurring early and a slower rate of decomposition occurring later. Several months after maize maturity we are most likely sampling during a period of slower root decomposition.

We also questioned the lack of accumulated root mass from years previous to our experiment. We were careful to collect maize root samples 20 cm from our maize row and to plant our rows within 2-3 cm of the previous year's row. We assumed that the cropping legacy from years past would have left a more homogenous distribution of roots than the one we implemented.

2) The maize-root C profile is presented 3 times in the paper: 1) Fig 1 b, 2) Fig 2, and

3) Fig. A3. The 3 figures are in the same units (Mg ha-1), but I could not reconcile the data between them. The 2013 data of fig. 1 b (with largest root accumulation in the top soil) do not seem to correspond to the 2013 data of figure A3, which seems to show highest maize-root biomass in the deeper soil.

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You are correct in not being able to reconcile the figures in the paper (1b and 2) with the figures in the appendix (A3) because the depth increments are not the same. Figure A3 shows the actual data, mass collected at 0-5, 5-15, 15-30, 30-60, and 60-100 cm depths. For example, the deepest depth increment is 40 cm long, resulting in high values relative to 5-15 cm, only 10 cm long. We used the values taken in these depth increments to break distribution into 5 cm increments, as described in P6, L 3-4. This gave a more accurate depiction of the distribution of both roots and organic C through the soil profile, shown in Figs. 1 and 2.

In addition, the maize root profile appears more even in Fig.2 than in Fig. 1 b, while it should be exactly the opposite (e.g. the 5-10 cm should have about half of the 0-5 cm in fig 2, if extrapolated from fig 1). Or are the two figures exactly the same? But why figure 2 then? The 3 figures should have been reconciled and presented as one main figure in logical units, and then the results compared to the literature.

Fig. 1b and Fig.2 are drawn from the same dataframe. Fig. 1 shows distribution patterns that, as you point out, are not visible in Fig. 2, especially for maize. We use Fig. 1 to discuss root and soil C distribution in the soil profile. Figure 2 shows absolute differences in root pool mass among treatments, not visible in Fig. 1. Fig. 2 is used to point out and discuss these basic differences.

3) Data from the root regrowth cores are not clearly presented, but used for a direct extrapolation of a root turnover rate in the top 30 cm. Summary data (without statistics) are presented in g m-2 in Table 4, making it difficult to compare to the root pool data presented in Mg ha-1. The maize root productivity appears low and I am missing a coherent evaluation of the C input in the context of published studies.

Sorry these data are not clear, we will improve this in the paper as well as change the units to correspond with other reported units. The maize root productivity is low because samples were taken 2-3 months after maize maturity, which we will also highlight.

4) The implications for C storage presented in this paper are largely hypothetical and somewhat contradictory. The present paper contains no significant result to link root biomass profiles to soil C profiles. While it is OK to briefly elaborate about possible implication of a higher root C/N ratio with depth, this should not be the main part of the discussion, which should instead focus on actual significant results.

The implications for C storage presented in this paper are partly hypothetical, but are complex and novel enough to warrant extensive discussion. The mystery of the disproportionally large stock of SOM relative to root C input found in deep soil has been unsolved since first noticed over 100 years ago and root C:N ratio increase with depth is a new and useful piece of information. We do not have direct evidence to link root biomass profiles to soil C profiles, but what we do have, combined with what we are able to model, is better than anything that has been previously published.

In addition, I could not reconcile the two ideas presented here about the effect of root C/N ratio on C storage in soils. On the hand, the authors argue that a lower C/N ratio for maize root favours C storage in soil as compared to prairie roots (p14, line 11-12). On the other hand, they also argue that an increasing C/N ratio of roots with depth in the soil profile also favours C storage (e.g. p1, line 10-12). The potential attempt to reconcile these two contradictory effects of root C/N ratio on soil C was unconvincing (p 14).

We will reword P1, line 10-12 - "In all treatments we found that root C:N ratios increased with depth, which may help explain why an unexpectedly large proportion of soil organic C is found below 20 cm." It is meant to suggest that increaseing C:N ratios with depth play a role in an unexpectedly large proportion of soil organic C found below 20 cm, not that the increase in C:N ratio directly contributes C storage. The relationship between C:N ratios and C storage is not necessarily intuitive, as we later describe in the text.

In conclusion, Dietzel et al. have collected an impressive data set on maize and prairie roots following maize-soybean rotation. The dataset appears to suffer from some artefacts, but root studies are difficult and shortcomings could have been acknowledged.

Thank you.

The data themselves are neither clearly presented nor sufficiently discussed in light of the literature. A main finding is largely ignored, i.e. the dramatic reduction of root biomass by fertilization in prairie systems.

Indeed, apart from the figures, we did include only three sentences on this finding. The effect of N fertilization on perennial root biomass is well-known (Troughton 1960, Thornley 1972, Gregory 2007) and we did not consider this plant response to be particularly important to a soils audience.

By contrast, the authors focus on an uncertain modelling and non-verifiable considerations about the effect of root C/N ratio on soil C. A focus on significant results and discussion of these results in light of the literature would have better served this study

While modelling is always uncertain, the fits of the models we used were very good and we stand behind the conclusions drawn from this effort. The effect of root C:N ratio on soil C may never be verifiable because it is a centuries-long process that is difficult to measure, but root C:N ratio plays some role in the development of the soil C profile. This manuscript is the very first to question this role and work with existing data to propose a mechanism by which root C:N ratio contributes to soil C profile development. It is our hope that by focusing our paper on root C:N ratios and current soil C profiles, we are inspiring and supporting future studies that will examine this important relationship more closely. Merely commenting on this possible relationship in a manuscript focused on a comparison of maize and prairie roots would not reach the intended audience or provide direction for related experiments.

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Interactive comment on SOIL Discuss., doi:10.5194/soil-2017-5, 2017.

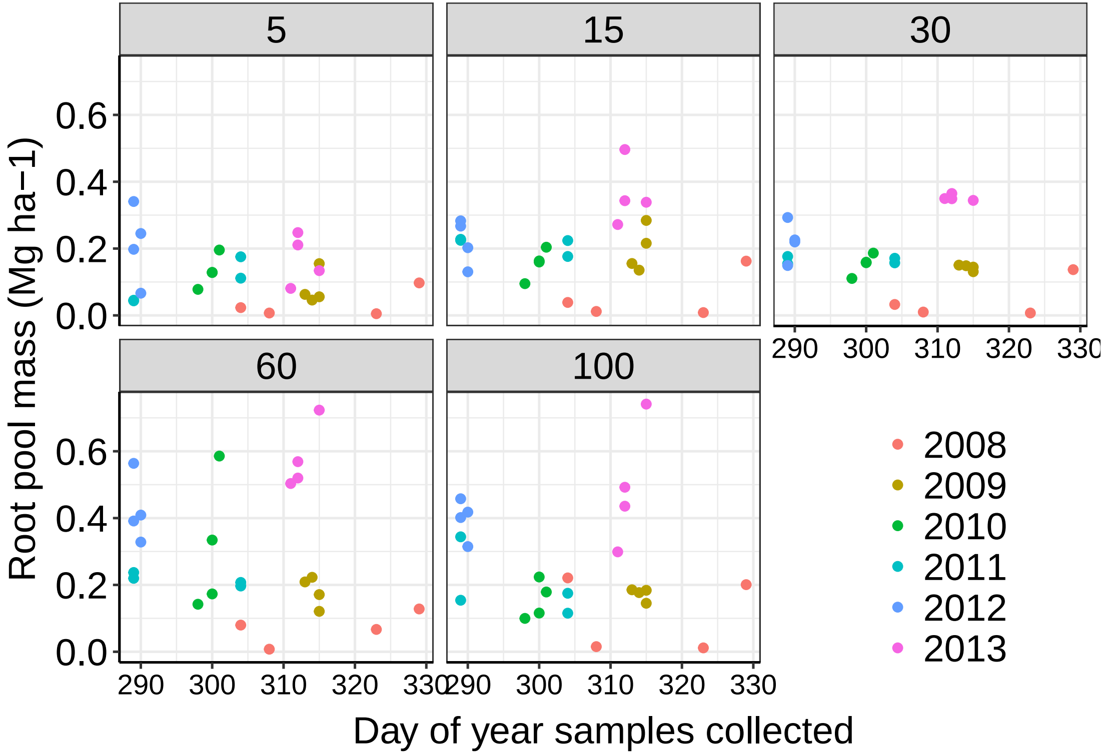

Fig. 1. Root pool mass by sampling time for each depth. 5 is 0-5 cm, 15 is 0-15 cm, 30 is 15-30 cm, 60 is 30-60 cm, and 100 is 60-100 cm.

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