

Response to reviewers' comments

Anonymous Referee #1

Received and published: 13 October 2015

I think the paper is a good piece of work and can be useful in improving our understanding of factors driving soil CO₂ emissions. However, there are many typo-grammatical errors that require significant attention. A few of the discussion points, e.g. around crop rotations and nitrogen fertilizer application, also need to be explored further.

- Corrections have been made as requested with a special attention on the discussion part. Please see comments below on this same page.

Anonymous Referee #1

Received and published: 14 October 2015

1. General comments While the paper is about an exciting and important subject, there are significant grammatical errors that require serious attention. It is understandable that many authors are not native speakers of the English language, but effort should be taken to have manuscripts edited by people with a good grasp of the language. There is also a lack of consistence in the style or structure of the discussion section. The author started off with short discussions under attribute based sub-topics and drifted to one long discussion where a number of attributes were lumped together. The danger in adopting the approach of the short discussions under specific sub-topics based on attributes is the interactions between/among the attributes e.g. the impact of most of the attributes analysed depend on length of time under adoption, climate, soil texture etc. It is often difficult to treat these factors independently in a discussion. Some results are poorly discussed e.g. the impact of (i) crop rotations, and (ii) nitrogen fertilizer application on SOC_C and CO₂ emission. There is no depth in the discussions and one wonders if the efforts in analysing the impact of these attributes were worthwhile.

- We fully agree about the difficulty to treat the factors independently in the discussion. However what we intended was to investigate the extent to which each factor impacted the till vs no-till differences for CO₂ emissions.

In the revised manuscript a specific discussion is given to crop rotation and fertilization impacts with a series of new research studies cited to explain the observed signals (underlined text as new adds):

4.5. Crop types, residues management and crop rotation

The no-tillage minus tillage variations of CO₂ emission and SOC_C between crop types are correlated with the quantity and quality of crop residue (Fig. 4a-b). Both quantity and quality of crop residues are important factors for soil carbon sequestration and CO₂ emissions, and are highly dependent on crop type. Reicosky et al. (1995), reported that corn returned nearly twice as much residue than soybean, and that soybean residues decomposed faster because of their lower C:N ratio. Thus, maize residues result in higher soil organic matter than soybean. Al-Kaisi and Yin (2005) also reported reduced soil CO₂ emissions and improved soil carbon sequestration in maize-soybean rotations due to better residue retention. Reicosky (1997) summarized that maximizing residue retention results in carbon sequestration with subsequent decrease in CO₂ emissions. However, several recent studies pointed to the lack of

impact of residue management on soil carbon, with Lemke et al. (2010) showing that crop residue removal in a 50 years experiment did not significantly ($P > 0.05$) reduce soil carbon, and Ren et al. (2014) showing that inputs from wheat straw and manure up to $22 \text{ ton ha}^{-1} \text{ yr}^{-1}$ could not increase soil carbon over 4 years. De Luca et al., (2010) explained the lack of crop residue impact on soil carbon by the very low amount of carbon in residues compared to the bulk soil in their study, while Russell et al (2009) having investigated several systems pointed out to a concomitant increase of organic matter decomposition with carbon input rates. Wilson and Al Kazi (2008) indicated that continuous corn cropping systems had higher soil CO_2 emissions than corn-soybean rotations because of a greater residue amount. Van Eerd et al. (2014) concluded from winter wheat - legumes rotations to higher carbon input during wheat cultivation, due to a greater belowground allocation. The present analysis suggests that tilled soils have significantly greater CO_2 emissions than no-tilled soils irrespective of the crop rotation system (Fig. 8).crop rotations than under no-tillage with tillage increasing the richness and diversity of active soil bacteria by increasing the rate of diffusion of O_2 and the availability of energy sources (Pastorelli et al., 2013).

4.6. Nitrogen fertilization

... This result could be due to the fact that nitrogen fertilization increases productivity and carbon inputs to the soil under both tilled and untilled systems, which may override nitrogen effects on decomposition such as shown by Russell et al. (2009). Increasing SOC as a response to nitrogen fertilization was found under no-tillage during a period of 4 years (Morell et al., 2010), and during the 50 yr experiment of Lemke, et al. (2010). Yet Sainju et al. (2008) reported the opposite: a 14% increase of soil CO_2 flux with nitrogen fertilizer, because fertilizer application stimulated biological activity, thereby producing more CO_2 , and causing SOC_C decline (Khan et al., 2007; Mulvaney et al., 2009). In contrast, Wilson and Al Kazi (2008) showed that increasing N fertilization generally decreased soil CO_2 emissions, with a maximum decrease of 23% from $0\text{-}135 \text{ kg N ha}^{-1}$ to 270 kg N ha^{-1} occurring during the growing season, which might be explained by a series of mechanisms, including the inhibition of soil enzymes and fungus and the reduction of root activity....

2. Specific comments

Pg. 15497 l. 9: : : ...been 'a' common practice in agriculture : : :
Yes we agree, 'a' was added on page 3 , line 12.

Pg. 15497 l. 13: : : : : .may also lead to the 'vertical and' lateral export : : : : :
Thank you. The suggestion was considered and we added new sentence (page 3, line 15-17), which reads; " Soil tillage may also lead to the vertical and lateral export of particulate and dissolved organic carbon by leaching and erosion (Jacinthe et al., 2002; Mchunu et al., 2011)".

Pg. 15497 l. 9-20: Why starting a new paragraph? Moreover, lines 16-19 make a very small paragraph.
The two paragraphs are now joined; Page 4, line 12.

Pg. 15497 l. 21: : : : , exposing 'the' protected : : : :
Done (page 4, line 3).

Pg. 15498 l. 6: suppress 'The' to start the sentence as 'Common wisdom is : : :'
'the' was suppressed. The new sentence now (page 4, line 13-15) reads "Common wisdom is that no-tillage (or zero-tillage) agriculture enhances soil carbon stocks (Peterson et al., 1998; Six et al., 2002; West and Post, 2002; Varvel and Wilhelm, 2008)....."

Pg. 15498 l. 11: suppress 'the' for the sentence to read ': : :reported that abandonment: : :'
'the' was suppressed (page 4, line 16).

Pg. 15498 l. 14: put a full-stop (period) to end the sentence ': : : : compared to tillage.'
Done.

Pg. 15498 l. 16 suppress 'under' for the sentence to read ': : : under no-tillage than tillage'.
Done (page5, line 2).

Pg. 15498 l. 17: suppress 'a' for the sentence to start 'While consensus: : :'
Done (page5, line 3).

Pg. 15498 l. 25: add 'depth' for the sentence to read ': : :soil sampling depth extended to: : :'
Done (page5, line 8).

Pg. 15499 l. 1: suppress 'from' for the sentence to read ': : :...under tillage than a no-tillage: : :'
The new sentence now reads (page5, line 11-12) "Evidence for greater CO₂ emissions from land under tillage than a no-tillage regime has been widely reported (e.g., Reicosky, 1997; Al-Kaisi and Yin, 2005; Bauer et al., 2006; Sainju et al., 2008; Ussiri and Lal, 2009)"

Pg. 15499 l. 8: format 'in situ' to italics because it is not an English word.
'In-situ' is now in italics.

Pg. 15499 l. 9: ': : :similar to those from tilled soils': : : suppress 'which were tilled': : :
The new sentence now (page 5, lines 15-17) reads "Al-Kaisi and Yin (2005) found this difference to be as much as 58%. A few in situ studies, however, found CO₂ emissions from no-tillage soils were similar to those from tilled soils (Aslam et al., 2000; Oorts et al., 2007; Li et al., 2010)".

Pg. 15499 l. 14: space required : : : : 'China,no-tillage': : :.
Thank you.

Pg. 15499 l. 16-18: poor grammar in this sentence. I also think this sentence is not adding any value and must be suppressed.
The whole sentence was suppressed.

Pg. 15499 l. 19: : : : 'soil compared to tilled soil to increased decomposition': : : : :
The new sentence now (page 6, lines 2-3) reads "Oorts et al. (2007) attributed the larger CO₂ emissions from no-tillage soil compared to tilled soil to increased decomposition of the weathered crop residues lying on the soil surface".

Pg. 15500 l. 2: : : ... ‘on the CO₂ efflux’: : : ...
‘the’ changed to ‘on’ page 6, line 12.

Pg. 15500 l. 24: format ‘in situ’ to italics
The correction was done (page 8, line 3).

Pg. 15500 l. 25: avoid starting a new sentence by ‘To’: : : .
The sentence changed (page 8, lines 4-5) to “In order to make the search process as efficient as possible, a list of topic-related keywords was used such as “soil carbon losses under tillage compared to no-tillage...”

*Pg. 15501 l. 13-15: the sentence is not clear. It is not normal to start a new sentence with the word ‘For’. Therefore, it is suggested that the sentence be rephrased.
The new sentence now (page 8, lines 13-14) reads; “However, only direct seeding and drilling were considered as no-tillage, among different practices reported in the literature”.*

Pg. 15501 l. 20: suppress ‘s’ and ‘of’ for the sentence to read : : : . ‘and average CO₂’: : : .
The new sentence now (page 8, lines 16-17) reads; “Table 1 summarizes information on site location, climatic conditions, crop rotation systems, and average CO₂ emissions under tilled and untilled soils”.

Pg. 15501 l. 22: suppress ‘that’ and use a better word in place of ‘made’
The new sentence now (page 9, line 1-2) reads “There was only one study from Africa, conducted in Kenya by Baggs et al. (2006)”.

Pg. 15501 l. 23: suppress the comma (,) after SOCC
The comma was removed.

Pg. 15501 l. 24: suppress ‘the’ after ‘In addition’,
“the” was suppressed.

Pg. 15501 l. 27: suppress comma (,) after management
The comma was removed.

Pg. 15502 l. 3: add ‘in terms of’ after ‘gave SOCC’,
The correction was done, the new sentence now (page 9, lines 8-9) reads “Four studies (Hovda et al., 2003; Álvaro-Fuentes et al., 2008; Lee et al., 2009; Dendooven et al., 2012) gave SOC_C, as the mass of carbon in the 0-0.03 m layer and per unit area (kg C m⁻²)”.

Pg. 15502 l. 4: do not start a sentence using the word ‘For’
The sentence was changed (page 9, lines 8-11) to “Finally, for the remaining studies, SOC_C was extracted from existing papers describing measurements at the same site. SOC_C was estimated from the soil organic carbon stocks (SOC_S kg C m⁻²) and bulk density following Eq. (1) by Batjes (1996)”.

Pg. 15502 l. 5-7: Who used the formula to estimate SOC_C? If the formula was used by papers used for the review, then there might be no need to present it here. However, the formula has to be mentioned together with the reference.
The formula is commonly used. However, the sentence was improved (page 9, lines 9-11) to “Finally, for the four remaining studies, SOC_C was extracted from other publications

describing measurements at the same site. SOC_C was estimated from soil organic carbon stocks (SOC_S kg C m⁻²) and bulk density following Eq. (1) by Batjes (1996)".

$$SOC_S = SOC_C \times \rho_b \times T \left(1 - \frac{PF}{100}\right) b$$

Pg. 15502 l. 23: do not start a sentence using the word 'For'

Thank You. The sentence was changed (page 10, lines 6-8) to "Fertilization rate for this meta-analysis was classified into the categories defined by Cerrato and Blackmer (1990): low when below 100 kg N ha⁻¹ and high when above 100 kg N ha⁻¹".

Pg. 15503 l. 2: use a plural for crop (i.e. crops)

The correction was considered.

Pg. 15503 l. 6: suppress 'the' for the sentence to read 'As a common practice, natural': : :

"the" was suppressed (page 11, line 2).

Pg. 15503 l. 17: suppress 'the' so as to read 'Overall, average': : :

"the" was suppressed (page 12, line 3).

Pg. 15503 l. 18-19: replace 'for those under' by 'from': : :

The correction was considered (page 12, line 4).

Pg. 15503 l. 21: suppress 'and was'

"and was" was suppressed. The new sentence now (page 12, lines 6-7) reads "The lowest soil CO₂ emission was 11 g CO₂-C m⁻² yr⁻¹ observed for no-tillage wheat in the humid climate of Lithuania (Feiziene et al., 2011)".

Pg. 15504 l. 1: suppress 'and was'

'and was' was suppressed.

Pg. 15504 l. 5: do not start a new sentence by the word 'For'

the sentence was changed (page 12, lines 11-12) to "Tillage emitted 27% more CO₂ than no-tillage in arid climates; while for pairs in humid climates, tillage emitted 16% more CO₂ than no-tillage".

Pg. 15504 l. 24: suppress 'the' so that it reads : : : 'abandonment on one hand and selected': : :

Suppressed.

Pg. 15504 l. 6-8: 'However, : : : climates' is not clear. Do you mean CO₂ emission from till and no-till soils were not significantly different in each of the two climatic zones, or there were no significant differences between the two climates?

We meant that the differences of CO₂ emissions between tilled and no-tilled do not significantly differ between the two climatic zones.

Pg. 15504 l. 11: suppress 'under' and 'for'

'under' was Suppressed.

Pg. 15504 l. 12: not clear whether statement refers to SOCC between till and no-till in each for each climate or are comparing between the two climates. Rephrase this part to make it clearer.

The new sentence now (page12, lines 14-16) reads “In arid climates, SOC_C in tillage was 11% lower than no-tillage, whereas in humid climates SOC_C under tillage was only 8% less than for no-tillage. However, the differences in SOC_C between the two climatic zones were found to be non-significant”.

Pg. 15504 l. 15: suppress ‘soil organic carbon content’ because SOCC has already been used countless times before

Yes we agree.

Pg. 15505 l. 4: insert a comma (,) after ‘soils’

Done.

Pg. 15505 l. 5-6: not clear, otherwise the sentence appears to add no value at all

The sentence was suppressed.

Pg. 15505 l. 12: ‘and untilled soils’. Suppress ‘positive’

The word ‘positive’ was suppressed.

Pg. 15505 l. 17: do not start a new sentence by the word ‘For’

The sentence was changed (page14, lines 3-4) to “SOC_C under no-tillage was slightly greater than under tillage for soils under fallow, but the difference was not significant (Fig. 4b)”.

Pg. 15505 l. 18: change ‘is’ to ‘was’

this was changed; the new sentence copied above to this comment.

Pg. 15505 l. 19: suppress ‘negative’

The word ‘negative’ was suppressed.

Pg. 15505 l. 25: suppress the comma (,) and replace ‘but a’ with ‘and’ and then suppress ‘difference’ and ‘lasting’ on pg. 15506 l. 1.

The new sentence (page 14, lines 8-10) now reads “However, there was a tendency for the differences between tillage and no-tillage to increase with increasing duration of the no-tillage regime with an average 18% difference for experiments of less than 10 years, and 23% for those longer than 10 years (Fig. 5a)”

Pg. 15506 l. 1: suppress ‘In the meantime’

This was suppressed.

Pg. 15506 l. 4: replace ‘lower’ by ‘shorter’

‘lower’ was replaced with ‘shorter’.

Pg. 15506 l. 6-11: Why is there is no result comparing SOC_C under till and no-till soils? Was it not important?

Because the SOC_C differences between tillage and no-tillage was almost the same under high and low nitrogen fertilizer application, we think it is not important to present in the text since it is already presented in Fig.6B

Pg. 15506 l. 16: was the difference of 18% significant?

Yes. It is indicated now in the text.

Pg. 15506 l. 17: ‘and only 5% lower when’: : .

Thank you, done.

Pg. 15506 l. 18: ‘Soils under a crop rotation regime exhibited much’: : .

We agree and the sentence now (page 15 , lines 6-8) reads “On the other hand, soils under a crop rotation regime exhibited much sharper decrease (i.e. 26%) of CO₂ emission following tillage abandonment than the soils under continuous monoculture for which changes of CO₂ emission were not significant at $P < 0.05$ ”.

”

Pg. 15507 l. 4: ‘Axis 1 could, therefore, be’: : .

Yes we agree, the new sentence (page 15 , lines 15-16) reads “Axis 1 could, therefore, be regarded as an axis setting clayey organic and warm soils against compacted, sandy soils from a cold climate”.

Pg. 15507 l. 9-10: what are ‘cool sandy and dense soils’ and ‘warm clayey’: : .? Are they ‘sandy and dense soils under cool climates’ and ‘clayey soils under warm climates’..?

Yes.

Pg. 15507 l. 13: : : . . . impact ‘on’ decreasing: : .

Thank you, ‘in’ changed to ‘on’.

Pg. 15507 l. 14-16: suppress the second ‘in’ and ‘from’ so that it reads : : . . ‘with 10% lower SOCC in tilled than untilled soils and 21% greater CO₂ emission from tilled than untilled soils’. You may also need to consider rephrasing this part so that you avoid repeating ‘tilled and untilled soils’.

The sentence was rephrased (page 17, lines 3-4) as “Our meta-analysis shows that tillage has a significant impact on decreasing top-soil (0-0.03 m) organic carbon content (SOC_C) and increasing CO₂ emissions, with 10% lower SOC_C and 21% greater CO₂ emission in tilled compared to untilled soils”.

Pg. 15507 l. 21: suppress the second ‘under’ so that it reads : : . . ‘greater CO₂ emission under tillage than no-tillage’: : .

Done.

Moreover, l. 20-25 need to show the contrasts in SOCC and CO₂ from the different authors cited. You assume, in the present lines, that a contrast in SOC_C and CO₂ emission automatically mean a contrast in CO₂ emissions under the different tillage practices. Is this always the case? I think other factors limit this assumption. Therefore, it is important to compare the contrasts in CO₂, and then the contrasts in SOCC!

➤ *Thanks you for the suggestion. The text was changed accordingly to highlight the contrasts for CO₂ emissions and SOC_C :*

*“4.5. Crop types, residues management and crop rotation
General paragraph summarizing the results:*

The no-tillage versus tillage variations of soil CO₂ emission and SOC_C were significant across crop types (Fig. 4a-b) but not across different residue managements (Fig. 7a-b). This is a surprising result because crop residues left on the soil surface under the no-tillage regime are expected to protect the soil against water and wind erosion (Ussiri and Lal, 2009), and improve soil aggregate stability (Chaplot et al., 2012), thus limiting soil carbon losses before becoming soil carbon through decomposition and organic matter incorporation to soils.

Crop type impact for SOC_C

Reicosky et al. (1995) and Wilson and Al Kazi (2008) reported increased SOC_C under maize monoculture compared to maize-soybean rotations, because maize returns nearly twice as much residue than soybean, and as soybean residues decompose faster because of a lower C:N ratio. In addition, Van Eerd et al. (2014) using winter wheat in rotations concluded in higher carbon allocation to soils, which was attributed to greater belowground carbon inputs by cereals than legumes. Reicosky (1997) and Al-Kaisi and Yin (2005) also reported improved soil carbon sequestration with

Crop types impacts on CO₂ emissions

decrease in CO₂ emissions under maize than soybean rotations due to better residue retention.

Residue impact on SOC_C

However, several recent studies pointed to the lack of impact of residue management on soil carbon, with Lemke et al. (2010) showing that crop residue removal in a 50 years experiment did not significantly ($P > 0.05$) reduce soil carbon, while Ren et al. (2014) showed that inputs through wheat straw and manure up to 22 ton ha⁻¹ yr⁻¹ couldn't increase soil carbon over 4 years. De Luca et al., (2010) explained the lack of crop residue impact on soil carbon by the

Residue impact for CO₂

very low amount of carbon in residues compared to the bulk soil, while Russell et al (2009)

having investigated several systems pointed to a concomitant increase of organic matter decomposition with carbon input rates. The present study tends to confirm the low impact of crop residue retention on the till vs no-till differences in CO₂ emissions and SOC_C. Crop type and rotation significantly impact on tillage effect on soil carbon and their role needs further appraisal.

Crop rotations impact for CO₂

Finally, the present analysis suggests that tilled soils emit significantly greater CO₂ emissions than no-tilled under crop rotation system (Fig. 8). This is likely because crop rotation increases SOC_C, and microbial activity and diversity. For instance, Lupwayi et al. (1998, 1999) found greater soil microbial biomass under tillage legume-based crop rotations than under no-tillage with tillage increasing the richness and diversity of active soil bacteria by increasing the rate of diffusion of O₂ and the availability of energy sources (Pastorelli et al., 2013). This study showed that continuous monoculture did not result in significantly different CO₂ between tilled and untilled soils (Fig. 8a). Rice is one crop often produced under a continuous

monoculture practice, however, in this meta-analysis, paddy rice did not show significant difference of CO₂ emissions between tillage and no-tillage. Li et al. (2010) and Pandey et al. (2012) attributed the lack of difference to anaerobic soil conditions occurring under both practices.”

Pg. 15508 l.1: suppress the first ‘the’ so that it reads : : : : ‘moisture content and amount’: : ‘the’ was suppressed.

Pg. 15508 l. 9-12: I suggest ‘At humid sites, high soil moisture favor high decomposition rates resulting in little differences between tilled and untilled soils, while large differences develop in arid climates with much lower soil water content (Fortin et al., : : :)’ : : :
The suggestion was considered the new sentence now (page17, lines 18; page 18, lines 1-2) reads “At humid sites, high soil moisture favors high decomposition rates resulting in small differences between tilled and untilled soils, while large differences develop in arid climates with lower soil moisture (Fortin et al., 1996; Feiziene et al., 2011)”.

Pg. 15509 l. 6: : : : : ‘soil aggregates within the top-soil’: : :..
Yes we agree. The sentence now (page 18, lines15-18) reads “Hence, the greater difference of CO₂ emissions between tilled and untilled soils for carbon-depleted soils compared to carbon-rich soils may be due to much greater stabilization of extra SOC delivered to the carbon-depleted soil by protection in soil aggregates within the top-soil (0.0-0.05 m) layer”.

Pg. 15509 l. 11-19: why is the impact of soil texture on SOC_C not discussed? Was it not an important result?

Yes, this aspect has been totally omitted, initially on purpose since the paper was about CO₂ emissions. We added the impact of soil texture on SOC_C

4.3.2. Soil texture

- *Soils under zero tillage emitted less CO₂ than tilled soils, and the CO₂ emission difference was the greatest in sandy soils (Fig. 3). Further, in sandy soils, as indicated by Fig 3, the largest CO₂ emission difference is mirrored by the largest SOC_C difference..*
- *Greater SOC_C and then CO₂ differences under sandy soils might be due to the lower resistance of soil aggregates to disaggregation, with tillage accelerating aggregate breakdown and decreasing organic matter protection, which causes a fast loss of soil carbon. Another reason for the greater response of sandy soils to tillage could be the fact that sandy soils become more porous when tilled, thus allowing changes in soil management to translate into large variations in the gas fluxes to the atmosphere (Rastogi et al., 2002; Bauer et al., 2006).”*

Pg. 15510 l. 6: : : : ‘less than 10 years old’.

Yes we agree.

Pg. 15510 l. 7: suppress ‘s’ to read : : : ‘no-tillage lead to carbon’: : : why were there carbon losses in the first years? You probably need to explain this in brief.

The new sentence now (page 20, lines 2-4) reads “Further, in some cases no-tillage leads to carbon loss in the top-soil layer (0-0.3 m) during the first years of adoption (Halvorson et al., 2002; Six et al., 2004), a response which can be attributed to slower incorporation of surface residues into the soils by soil fauna”.

Pg. 15510 l. 12: below 0.1 m? Is 0.1 m a measure of soil carbon? Again, there is probably need to explain why the soil carbon decreases in long-term no-till as suggested/ indicated by the sentence.

We meant the depth of the soil layer. The corrected sentence (page 20, lines 4-6) is “However, different studies give contrasting results; for instance, the long-term no-till experiments in northern France by Dimassi et al. (2014) showed that SOC increased in the top-soil (0-0.1 m) during 24 years after tillage abandonment, then did not increase, whereas SOC continuously decreased below 0.1 m.

Pg. 15510 l. 13: another attribute is now being discussed i.e. crop residue management! There is need for consistence in how the discussion is structured. If authors decided to use short discussions with sub-headings, so be it and they need to stick to that style.

Short discussions with sub-heading were considered throughout the manuscript.

Pg. 15510 l. 26: suppress ‘finding’ to read : : : : ‘also reported reduced soil’: : : : :
‘finding’ was suppressed.

Pg. 15511 l. 3-6: why this very short paragraph? I suggest this be made a part of the previous paragraph with an interchange of the 2 lines in this very short paragraph, as follows : : : : ‘in CO₂ emissions. This result can, however, explained by the very low amount of carbon in crop residues compared to the bulk soil (Luca et al., 2010). However, our analysis seems to suggest that climate and SOC are stronger controls of soil CO₂ emissions than the availability of crop residues’: : :

We did so, thank you.

Even when re-arranged like this, the statement : : : : ‘very low amount of carbon in crop residues compared to the bulk soil’ require further clarification because one generally expects organic matter to contain a greater amount of carbon than soil!

Thank you, the suggestion was considered. The new sentence now (page 21, lines 2-5) reads “De Luca et al., (2010) explained the lack of strong impact of crop residues on soil carbon by the very low mass of carbon in residues compared to that already present in the bulk soil,...”

Pg. 15511 l. 7: another case requiring consistence. It may also be difficult to understand a ‘tilled fallow’ unless this was for pure experimenting. There is, probably, need to improve this sentence to make it more meaningful.

The paragraph (Page 21, lines 5-8) was improved accordingly “The large difference in CO₂ emissions between tillage and no-tillage during fallow period is consistent with with observations made by Mosier et al. (2005), who documented higher CO₂ emissions from tilled soils during fallow in northern Colorado. However, Curtin et al. (2000) found no significant difference in CO₂ emissions between tillage and no-tillage during the fallow phase of a fallow–wheat rotation in on a gentle slope of katchewan, Canada.

Pg. 15511 l. 10: CO₂ ‘emmission’??? This must be a wrong spelling.
Typo corrected

Pg. 15511 l. 12: consistence required. I also find the discussion in this paragraph (l. 12-17) very limited and rather poor. Do the authors assume crop rotations are only possible in tilled

systems only? One expects a comparison of crop rotation and monoculture impact on SOC_C and CO₂ under tilled systems, and then a comparison of the same under no-till systems.

Page 21, 15-18 and page 22- lines 1-4

We have reworked extensively this part as follows:

General paragraph summarizing the results:

The no-tillage versus tillage variations of soil CO₂ emission and SOC_C were significant amongst the crop types (Fig. 4a-b) while residue retention appeared to be insignificant (Fig. 7a-b). This was a surprising result because crop residues when retained on the soil surface under the no-tillage regime are expected to protect the soil against water and wind erosion (Ussiri and Lal, 2009), and improve soil aggregate stability (Chaplot et al., 2012), thus limiting soil carbon losses before becoming soil carbon through the process of decomposition and organic matter incorporation to soils.

Crop type impact for SOC_C

Reicosky et al. (1995) and Wilson and Al Kazi (2008) reported on increased SOC_C under maize monoculture than maize-soybean rotations because maize returns nearly twice as much residue than soybean, and as soybean residues decompose faster because of a lower C:N ratio. In addition, Van Eerd et al. (2014) using winter wheat in rotations concluded in higher carbon allocation to soils, which was attributed to greater belowground carbon inputs by cereals than legumes. Reicosky (1997) and Al-Kaisi and Yin (2005) also reported improved soil carbon sequestration with

Crop type impact for CO₂

subsequent decrease in CO₂ emissions under maize than soybean rotations due to better residue retention.

Residue impact for SOC_C

However, several recent studies pointed to the lack of impact of residue management on soil carbon, with Lemke et al. (2010) showing that crop residue removal in a 50 years experiment did not significantly ($P > 0.05$) reduce soil carbon, while Ren et al. (2014) showed that inputs through wheat straw and manure up to 22 ton ha⁻¹ yr⁻¹ couldn't increase soil carbon over 4 years. De Luca et al., (2010) explained the lack of crop residue impact on soil carbon by the

Residue impact for CO₂

very low amount of carbon in residues compared to the bulk soil, while Russell et al (2009)

having investigated several systems pointed to a concomitant increase of organic matter decomposition with carbon input rates. The present study tends to confirm the low impact of crop residue retention on the till vs no-till differences in CO₂ emissions and SOC_Cs. Crop type and rotation

Crop rotations impact for CO₂

Finally, the present analysis suggests that tilled soils emit significantly greater CO₂ emissions than no-tilled under crop rotation system (Fig. 8). This is likely because crop rotation increases SOC_C, and microbial activity and diversity. For instance, Lupwayi et al. (1998, 1999)

Pg. 15511 l. 18-23: should be merged with the previous paragraph, because both of them are related to the effect of crop rotation and/or monoculture.

Yes we agree.

Pg. 15511 l. 24: new attribute being discussed! L. 25: replace the period or full-stop (.) by a comma (,) to read : : : ‘fertilizer level (Fig. 6a), a result’: : :..

Yes we agree. The new sentence now (page 22-lines 1-3) reads; “The differences of CO₂ between tillage and no-tillage did not differ with nitrogen fertilizer level (Fig. 6a), confirming observations by Alluvione et al. (2009) and Almaraz et al. (2009b)”

Pg. 15511 l. 26: change ‘These results’ to ‘This result’: : :.

Thank you. It is corrected.

Pg. 15512 l. 2: replace ‘:’ by ‘;’ so that it reads : : :.. ‘the opposite; a 14%’: : :.

Corrected

Pg. 15512 l. 10-11: suppress ‘highly’ and add ‘more’ to read : : : : :. ‘are likely to be disaggregated more by tillage’: : :.

Corrected

Pg. 15512 l. 13: replace ‘this’ by ‘which’ to read : : : ‘aggregate dispersion, which explains’...

Corrected

Pg. 15512 l. 14-16: sentence does not add any value here. I suggest (either) suppressing it (or taking it elsewhere).

Sentence was suppressed.

Pg. 15512 l. 16-18: check grammar. I suggest ‘It appears the cessation of tillage impact on CO₂ emission is not controlled by surface mulch limiting the contact between fresh dead organic material and the soil matrix and soil organisms’. However, I still do not understand how the mulch limits the contact between organic material, soil matrix and soil organisms because the mulch itself is often of organic nature; unless the authors are talking about other special mulching materials (e.g. plastics). This may need to be stated explicitly, otherwise common knowledge is to use crop residues for mulching.

This sentence has been deleted

Pg. 15512 l. 25: suppress ‘and’ to read : : :.. ‘inputs (from observation sites) used’: : :.

‘and’ was suppressed.

Pg. 15513 l. 1: either suppress or replace ‘this’ by ‘the’

Corrected.

Pg. 15513 l. 13: add ‘more’ to read ‘: : :.. ‘activity more under’: : :

Thank you, it was added (page 24, line 7)

Pg. 15513 l. 13-15: why a paragraph? Moreover, the last part of the sentence after the comma does not seem to add any value here.

Yes we agree and the part after (,) was removed; the new sentence now (page 24, lines 7-9) reads; “These results emphasize the importance of including soil factors such as texture, aggregate stability and organic carbon content in global models of the carbon cycle.

Pg. 15513 l. 16-20: this information is misplaced. One cannot expect this in a conclusions section. Please, can you find ‘a home’ for this in your discussion section or just suppress it.

Thank you, the sentence was suppressed.

Anonymous Referee #2

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General comments

This manuscript presents an important analysis of soil organic carbon stocks (SOCs) and CO₂ emissions changes in response to tillage treatments. The authors identify major driver of these changes using very rich dataset from 46 peer-reviewed papers and discuss their findings in a careful and comprehensive manner. This work is clearly an important contribution to the literature surveying the state of the art in terms of tillage impacts and highlighting important aspects that could improve models. Overall, the paper is clearly structured and is in the scope of Biogeosciences, thus is suitable for publication.

P. 15500, l. 25: I think it would be helpful for the reader if you explain better if CO₂ emissions are derived from only soil heterotrophic respiration or both autotrophic and heterotrophic. Precision on that should be included.

Here we considered total soil respiration, i.e. the sum of heterotrophic and belowground autotrophic respirations. This is now clearly stated in the materials and method section of the revised manuscript:

Page 8 lines 8-10: *“Many studies reported soil CO₂ emissions and SOC for cropland systems, but only those that reported CO₂ emissions measured in the field for both tillage and no-tillage from the same crop and during the same period were used. In addition, we selected only studies that consistently reported total soil respiration (heterotrophic + belowground autotrophic respiration).”*

P. 15503, l. 20: I suggest authors to present soil CO₂ emissions in relation with the yearly amount of C input which may improve the paragraph 3.1 and give an idea about the mineralization order of magnitude. These statistics about C input should be added, also, in the table 3. The amount of yearly C input helps authors to deeply interpret data and to explain such differences in CO₂ emissions rather than a simple description of results.

> This information was unfortunately not systematically available

I would suggest authors to cite recent literature which would provide more robust support for claims made in the paper. May be you could discuss the results of this study in comparison of yours (e.g. Powlson, D. S et al., 2014. Limited potential of no-till agriculture for climate change mitigation. nature climate change).

➤ Done

The authors did not take use of data on isotopes, if they exist, or discuss its use in evaluating SOC stocks change and the mean residence time. A few sentences on this kind of data in the discussion could add to the already thorough discussion.

➤ We did not find isotopic data for studies that met the above selection criteria

The perspective of models use seems exciting and authors suggest some models (e.g. RothC, Century, and DNDC). It's curious, however, how authors intend to simulate the tillage effect; some sentences on this could be nice.

Finally, I would encourage authors to explore implications of their findings in relations with other tillage practices such as rotational tillage.

➤ This analysis was attempted but we did not find sufficient data to compare different tillage practice

Technical comments

P. 15499, l. 14: “China,no-tillage” space is required

Done.

P. 15502, l. 8: Why variables SOC_c and b, are replaced by x1 and x2 in the equation 1. x1 and x2 are not used later. I would suggest to rewrite the equation with SOC_c and b.

The equation was changed to;

$$SOC_s = SOC_c \times \rho_b \times T \left(1 - \frac{PF}{100}\right) b$$

Where SOC_s is the soil organic C density (kg C m⁻²); SOC_c the soil organic C content in soil particles smaller than 2 mm (g C kg⁻¹ soil); ρ_b the bulk density (kg m⁻³); T the thickness of the soil layer considered (m); PF the proportion of soil particles larger than 2 mm (percent) ; and b is a constant equal to 0.001.

P. 15504, l. 8: add "fig. 1a" to the sentence; “: :and humid climates (Fig. 1a)”

Yes we agree. The new sentence now (page 12, lines 12-13) reads; “However, the differences in CO₂ emissions between tillage and no-tillage were not statistically significant (at 0.05 confidence interval) between arid and humid climates (Fig. 1a)”.

P. 15505, l. 1: Authors may need to rephrase the two first sentences to avoid repetitions of “soils” used 7 times. You may use treatments instead of tilled and untilled soils.

The new sentences now (page19, lines 6-8) read; “Differences in CO₂ emissions between treatments were greater in sandy than in clayey soils (Fig. 3). This might be due to the fact that sandy soils have higher porosity, allowing changes in soil management to translate into large variations in the gas fluxes to the atmosphere (Rastogi et al., 2002; Bauer et al., 2006)”.

P. 15507, l. 13: The sentence is too long; authors may need to rephrase it in a concise way.

The new sentence (page 17, lines 3-4) reads “Our meta-analysis shows that tillage has a significant impact on decreasing top-soil (0-0.03 m) organic carbon content (SOC_c) and increasing CO₂ emissions, with 10% lower SOC_c and 21% greater CO₂ emission in tilled than untilled soils”

P. 15513, l. 19: Correct the reference “Dimiss et al (2013)” by “Dimassi et al. (2013).

The reference was corrected.

P. 15527: fig. 1 precise if it's SOC content or stocks, same comment for figures 3, 4, 5, 6, 7 and 8

Yes we agree : SOC_c was used for all figures.

Interactive comment on Biogeosciences Discuss., 12, 15495, 2015.

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P15501L13 "To our knowledge, Baker et al. (2007) was the first to point out that the studies concluding on carbon sequestration under no-tillage management had only considered the top-soil (to a maximum of 0.3 m), while plants allocate SOC to much greater depths."

Actually it was briefly pointed out in a report of the Royal Society (2001) that lack of adequate depth of sampling could omit the total C stock and thus favor C storage under no-till. It was further illustrated by VandenBygaart and Angers (2006) who highlighted the problem in relation to a meta-analysis conducted in the U.S. and depth profiles from a long-term experiment.

Royal Society 2001. The role of land carbon sinks in mitigating global climate change. Royal Society, London UK.

AJ VandenBygaart and DA Angers 2006. Towards accurate measurements of soil organic carbon stock change in agroecosystems. Canadian Journal of Soil Science 86:465-471.

➤ [These references have been included, Thank you](#)