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## ***Interactive comment on “Changes in soil carbon, nitrogen and phosphorus due to land-use changes in Brazil” by J. D. Groppo et al.***

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Received and published: 23 June 2015

C:N:P ratios – Both reviewers showed concern about the use of C:P ratio using P extracted by Mehlich-3 (PME) instead organic P (Po) or total P (PT).

Reviewer #1 - Concerning the C:N:P ratios: it is comprehensive to use the C:N ratio, these elements are part of the soil organic matter. But, it was showed in old works that it is not possible to use the P (as total-P determination) for soil samples (it is possible for organic materials), and the stoichiometry have to be done with the Po (organic P). And, in addition, the form of P that was compiled in the paper was a Mehlich-3 extraction, it's a double acid extraction that extracts phosphate ions and also dissolves some organic matter and then solubilise organic phosphorus.

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Reviewer #2 - The authors used P extracted by Melich-3 ("available P") as the P metric, which makes sense considering the focus on agricultural systems, the endpoint land use systems in the study. However, its hard to compare these data with other studies.

Answer – The original version of our paper did not include C:N:P ratios analysis. These ratios was incorporated in the paper following the suggestion of the handling editor Sébastien Fontaine that proposed the following: "the analysis of data remains too descriptive presenting a succession of N and P stocks in different land uses. A more analytical approach of data analysis taking into account the ratio between elements (C/P/N), the stoichiometric constrains of biological organisms and agricultural systems is necessary for the audience of BG Journal.".

We tried to attend such suggestion with the P data that we had in hand (PME). In this new version of the paper we also made explicitly that this is not a common, citing that it is much more common to use C:Po, since most of the soil carbon is in the form of organic carbon. Alternatively some more recent papers used C: PT, which includes organic and inorganic forms of soils. In the new version of the manuscript we stated the following on page 7, line 186:

Phosphorus concentration was determined by extracting soil phosphorus using the Mehlich-3 method of extraction (Mehlich, 1984), and phosphorus concentration was quantified by the colorimetric blue method. Accordingly, the C:P and N:P ratios shown here did not use organic phosphorus (Po) concentration as usual (e.g. Walker and Adamas, 1958; McGill and Cole, 1981; Stewart and Tiessen, 1987) or total phosphorus (PT) like used by Cleveland and Liptzin (2007), and Tian et al. (2010), but Mehlich phosphorus concentration (PME), which is a mixture of inorganic and organic phosphorus fractions that are at least theoretically more available to plants (Gatiboni et al., 2005). As this is less common, because most paper presents C:Po or C:PT ratios; the use of PME makes difficult comparison with results obtained elsewhere; this fact constraint the use of C:PME or N: PME ratios only useful for an inter comparison between our study sites. On the other hand, the use of such ratios could incentivate a

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more widespread use of them, since PME determination is much less laborious than the determination of Po by the sequential extraction proposed by Hedley et al. (1982).

On the phosphorus issue, reviewer #1 also made the following comments: 1. Concerning phosphorus: avoid the term “fix” (page 4-line 9), prefer adsorption like line 19. In general it's not a lack of phosphorus in tropical soil (concerning Brazil, the stocks of total-P are high regarding others tropical cultivated lands, even in sandy soils developed on sandstones of the Paraná and Bahia ...), but a low concentration in phosphateion in the soil-solution and a hard competition of roots with the soil-solid phase which retains with a high energy the phosphate.

Answer: We thank the reviewer for this suggestion. We understood that term “fix” is more a jargon; and also that available P is in short supply and not total-P. The term “fix” was replaced in the manuscript by “adsorption”.

2. In my comprehension, the authors are not “phosphorus specialists” and use with some misconceptions the knowledge of this topic (there are others evidences in the ms).

Answer: This is absolutely true, the authors in general are much more familiar with carbon and nitrogen than phosphorus, and we are glad that our paper was reviewed by someone more familiar with phosphorus.

3. Page 5, lines 4 to 19, now days a part of the scientific community, which never worked with soils (?) rediscover the C:N and C:P ratios. The reality is quite different, from 100 years we used the C:N for comparisons of global conditions of capacity decomposition of organic material; it is the same for the C:Po ratio, ie the rate of decomposition of Po. (organic P) in litter and excreta, depends initially on the P solubility in the residue and subsequently on the rate of decomposer growth. The rate of decomposer growth depends on substrate accessibility to the organism and its enzymes, the chemical nature and nutrient content of the substrate (extent of lignification, C:N:P ratio) and the surrounding soil water (pH : : :).

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Answer: We are not sure if we understood the comment above. But, perhaps, the reviewer is suggestion that we acknowledge the earlier contributions on this topic. If this is the case we included in several parts of this new version citations of this “old school”, having in mind that the senior author of our paper (L.A.Martinelli) knew several of these authors: Holm Tiessen, John Stewart, Elder Paul, Paul Varonay, among others.

4. I understand that it is interesting to cite recent references, but here for this journal the importance is not to write “that changes in C:N:P ratios may affect several aspects of ecosystem functioning, including carbon sequestration, and, consequently ecosystem responses to climate change”, that is a general comment with no interest, but to explain in which way your proposal of the C:N:P evaluation is original and may serve a knew knowledge in biogeochemistry of soils, and by extension its consequences for management and a few comments on global changes.

Answer: We agree with the reviewers and in this new version we changed the phrase to: Besides concentrations and stocks, agricultural management are also capable of altering the ratios between carbon, nitrogen and phosphorus (C:N:P) (Tiessen et al., 1982; Tiessen and Stewart, 1983; Ding et al., 2013; Jiao et al., 2013; Schrumpf et al., 2014; Tischer et al., 2014). For instance, soil microorganisms adjusting their stoichiometry with that of the substrate may release or immobilize nitrogen depending on the substrate C:N ratio (Walker and Adams, 1958; McGill et al., 1979; Mooshammer et al., 2014a). In turn, litter decomposition also depends on the stoichiometry of the litter, especially on the C:N ratios (Hättenschwiler et al., 2011). These adjustments guided by C:N:P ratios may ultimate interfere in crop production, that in turn will affect soil carbon sequestration, and, consequently agro-ecosystems responses to climate change (Hessen et al., 2004; Cleveland and Liptzin, 2007; Allison et al., 2010).

5. In conclusion, I think that the introduction needs a reformulation.

Answer: Besides changes showed above, we also start the Introduction with a new paragraph that reads as follow:

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The demand for food will continue to grow in order to feed a population that will reach near 9 billion people in 2050 (Tilman et al., 2011). Brazil is one of the pivotal countries that will have a key role in the global food production system (Martinelli et al., 2010). There is already a consensus that increase in food production can't be achieved by the replacement of native vegetation by agricultural fields (Tilman et al., 2011). One of the alternatives that have been proposed is agricultural intensification, which not only means an increase in productivity but also an attempt to increase sustainability (Godfray et al., 2010). Sustainable agriculture (SA) has been proposed as one way to achieve both goals. The SA tries to mimic natural ecosystems by adding layers of complexity in attempt to departure from simplistic monoculture fields (Keating et al., 2010). Crop livestock systems (CPS) are a suitable example of this attempt to add layer of complexity to agricultural fields. Integrated crop-livestock or crop-livestock-forest, and agroforestry systems (CPS) are not a new idea. However, these systems have only been consolidated in recent decades (Machado et al., 2011). The system consists of diversifying and integrating crops, livestock and forestry systems, within the same area, in intercropping, in succession or rotation. The system can provide environmental benefits such soil conservation, build up soil carbon, reduce environmental externalities and ultimately increase productivity. CPSs include but are not restricted to: no till, the use of cover crops, elimination of agricultural fires (slash-and-burn), and restoration of vast areas of degraded pastures (Hou et al., 2008; Machado et al., 2011; Bustamante et al., 2012; Lapola et al., 2014). Additionally, the Brazilian law (Law no. 12187 of December 29, 2009), encourages the adoption of good agricultural practices to promote low carbon emission (Low Carbon Emission Program – ABC Program), and stipulates that mitigation should be conducted by adopting: (i) recovery of degraded pastures, (ii) a no-tillage system, (iii) integrated livestock-crop-forest systems, and (iv) re-forestation, in order to reduce approximately 35% to 40% of Brazil's projected greenhouse gas emissions by 2020 (Assad et al., 2013).

## OTHER COMMENTS:

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## MATERIAL AND METHODS

1. - page 7, line 12, now it is preferable to use Urochloa sp for the Brachiaria genus. Done

2. - Same page, lines 18-20, this comments concern Brazil add "in Brazil" in the start of the phrase. Done

3. - Page 8, section 2.1, the reference to the ABC program is interesting in a global pointof view, perhaps in another section it should be better, in particular in the discussion. Fixed

4. 2.2 / Climatic data, it is strange to refer to a north-american database, nothing in Brazil? Not for every single place that samples were collected. Full and operational meteorological stations are still sparse in Brazil considering the extension covered by our sampling.

5. 2.3 / Sampling. How many replicates for the soil bulk density? Which method? Answer: We added the following into this new version: Due to the high number of sampling sites and interval depths, only one soil sample for bulk density was collected by soil depth. We order to access the soil bulk density data see Assad et al. (2013).

6. When the coarse fraction is higher than 12-15 % in mass of total soil, the cylinder method is avoided : : : In the equation (1) it is not referred to the coarse soil fraction, do we understand that there is no coarse fraction? But it was written that "Air-dried soil samples were separated from plant material and stones : : : (2mm sieve ...)". In addition, for stocks evaluation, the coarse fractions have to be weighed in volumetric samples done for bulk density. So, as the paper is centred on stocks this section have to be performed (the real eq 1 is  $S=[X].z.\text{bulk density}.(1-y)$  were y is the mass  $> 2\text{mm}$  in g/gsoil). Answer: We are not sure if we can be sure that there was no a coarse fraction higher than 12-15% in mass of total soil, but certainly in most of the samples we had not that problem. The word "stone" was removed and the following was added to the

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equation description: S is the cumulative soil nitrogen or phosphorus stock for fixed depths in the soil mass < 2 mm in gram per gram of soil.

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1. Please indicate that the elemental analysis CN by combustion includes in the C concentration a possible part of charcoals. It is important if we consider that a large part of deforestation in Brazil had the fire as a basic technique, but also the soil fine charcoal is due to past climatic changes (Holocene or pre-Holocene) (Many Brazilian soils have more or less from 0.3 to 2 kg of C-charcoal per m<sup>3</sup> : : :). Avoid the word “available” for the phosphate extraction, as the colorimetric method is specific to phosphate it is preferable to use extractable phosphate for Pme. For some soils from the south, we are not sure that the colorimetric method is the better one (SiO<sub>2</sub> in solution, acid extractable effect) and the blue method is one of the methods to determine Si in solution.

Answer: We include the observation suggested by the author.

2. page 9 and 10, last part of the section 2.4, there is a long discussion about the conditions of sampling and the limitations. In my opinion this is interesting, but why no consolidate an uncertainty section in the discussion. In this way, there is no reference to the large diversity of soils which were sampled ...

Answer: We moved this part to the discussion as suggested by the reviewer.

## RESULTS

1. Why do you expected a decrease of concentrations with deep? Even in Brazil there are soils layers where you can have an augmentation of carbon in deep layers!

Answer: Because most soils show a decrease of C concentration with depth. But, we agree that there are notable exceptions and we deleted the word “expected”.

2. Preferable to use the Pme than phosphorus in this section, refer to the real analyse. Idem for the C:P, use C:Pme in the figures.

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Answer: We changed accordingly in the text and in the figures.

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## DISCUSSION

1. There is a long section on the C:P and N:P ratios, it is written “it is difficult to further speculate about the reasons of such trends”, perhaps it could be easier to refer to others papers which described and explain total-P and organic-P distribution in Brazilian soils!

Answer: We tried to be more precise and we modify this sentence accordingly:

2. Concerning the Pme extractions, the authors have only a reflexion on the absolute values and ratios. But the Mehlich is an acid extraction, so the extracted phosphate is an evaluation of the potential dissolution of phosphate, mainly inorganic+organic. Then, when those values increase in deep layers compared to non cultivated lands, at the scale of this large survey, it indicates that large part of phosphate is statistically extractable in those layers, so one of the effects of the diverse cultivations is the mobilisation of this phosphate fraction.

Answer: We tried to improve the discussion in that aspect by modifying the sentence that now reads as: ). One reason of this decrease in the C:PME ratio in the deepest soil layer could be the contribution of inorganic P through weathering (Tian et al., 2010), as attest by an increase of PME in the deepest soil layer in soils under native vegetation (Figure 2c). Another possibility in agricultural soils is that cultivation itself can promote mobilization of this phosphate fraction by addition of phosphorus fertilization and changes in soil physical properties (see discussion below, Fonte et al., 2014).

3. The other comment is that in CPS and pasture-R samples, the soils could similar, due to strategically survey decisions, and in consequence the effect of cumulative P-fertilisation is quite clear in figures and tables. In my point of view, not only the fertilisation had an effect, but also the cultivation in all compounds: its favours the remobilisation of phosphate soil fractions (they are some references in brazilian journals),

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and this point is essential to stress and comment.

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Answer: We think we addressed this point in the last sentence.

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4. In conclusion, if I agree with the discussion of the P fluctuation in the paired sites survey, I think that a more specific and detailed reflexion on the methodological approach for the P quantification is needed. In particular, in the page 19, the cited papers had differentiated methodologies, and the discussion is too general to overcome to Ânset a baseline of soil nutrients stocks and stoichiometry for future comparisons ÅŽz as authors wrote.

Answer: We think that in this new version we addressed the concerned expressed above by the reviewers.

## TABLES AND FIGURES

1. Table 2 and 3. Add the units in the title in order to simplify the table Done
2. Figure 2 and 3. Are those results means ? indicate in the title. The P is the Pme in fig 2, indicate. Done
3. Figure 4. The title of the fig is not clear, in which axis is the Assad data set? We changed the legend of the figures.

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Interactive comment on Biogeosciences Discuss., 12, 2533, 2015.

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