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Reply on RC2

Yuan Wang et al.

Author comment on "The distribution of phosphorus from phosphorus derived materials to different soil fractions determines the phosphorus availability in the soil" by Yuan Wang et al., SOIL Discuss., https://doi.org/10.5194/soil-2021-127-AC2, 2022

Dear Dr. Pistocchi,

We greatly appreciate your time and expertise in reviewing our manuscript (soil-2021-127). We have carefully modified the manuscript based on your constructive comments, which significantly improve the manuscript. Appended is our point-by-point response to the comments. The detailed information is as follows:

1. The main issue in my opinion is the lack of mechanistic interpretation of the reported findings. The effect of organic amendments or fertilizers on soil P has been investigated by several studies, see the non-exhaustive list of references reported below. The authors need to highlight better how their work allows advancing in the understanding of mechanisms driving P availability after the addition of organic amendments and what is the general interest of their research. This issue is also evident from the lack of scientific questions or hypotheses in the introduction, where only operational goals are reported (L98-103).

Good suggestion. The application of organic fertilizer in agriculture as a soil structure improvement and nitrogen source has been widely studied. While the problem of high environmental risk caused by a large amount of P in organic fertilizer is becoming more and more prominent. Therefore, this study focuses on the soil P transformation from different renewable P-containing materials and aims to quantify the variation of soil P availability on the time scale and in different soil types (representative of acidic and alkaline soils). Based on the suggestion, we supplement the scientific hypotheses in the

Introduction as follows: We hypothesized that□(1) Compared with MS, CB, and PM, CM is more efficient renewable P-containing materials. (2) Compared with fluvo-aquic soil, different P-containing materials are more easily fixed in red soil. (3) The difference in potential bioavailability of P from various sources is determined by their distribution to soil labile P fractions.

We attempted to explore promising renewable P-containing materials for achieving a closed cycle of P by understanding the transformation dynamics of different renewable P-containing materials in soil and their P availability. We have supplemented this background in the introduction. To understand the transformation dynamics of different P-containing materials in the soil, we measured the P fractions of the initial soil, four renewable P-containing materials, and two soils with different P-containing materials on days 0,35, and 70 of incubation. The P fractions were not significantly different on day 70 of incubation compared to day 0 of incubation. Therefore, we analyzed the data from day 70 of incubation in the manuscript. However, we did not realize that these data are indispensable to understanding the mechanisms of transformation of different P-containing materials in two soils. The analysis and discussion of these data have been supplemented in the modified manuscript. We believe that this study is helpful and meaningful for understanding the mechanisms of P-containing material transformation in different soils.

And the conclusions were modified as follows: Compared with other renewable P-containing materials, CM is a superior source for improving soil P availability in fluvo-aquic and red soils. Compared to fluvo-aquic soil, phosphorus from SSP, PM, and CM were more strongly immobilized in red soil. Further analysis of the P fraction of two soils with different P-containing materials at days 0,35 and 70 of incubation revealed that the distribution of CM to the soil labile P fraction was significantly increased compared to other renewable P-containing materials. And compared with fluvo-aquic soil, the contribution of different P-containing materials to the labile P fraction of red soil was significantly decreased. Changes in P fractions at different incubation periods in soils with different P-containing materials show that most soil P fractions have no significant difference on day 70 of incubation compared to day 0 of incubation. That suggests, in the short term, the difference of potential bioavailability of P from various sources is determined by the distribution to soil labile P fractions rather than its transformation in the soil. In general, there is promising potential to reduce P limitation by recovering cattle manure as an alternative source of P supply. This study provides a basis for closing the P cycle in agricultural systems and for sustainable on-farm P management strategies.

2. A second point is about the recycled fertilizer/amendment material: why these

specific materials were chosen? For example, why include maize straw, which is commonly left in the field and therefore does not constitute an external P input? In addition, these materials are poorly characterized. The total NPK contents are not sufficient to characterize these materials as already pointed out by the first reviewer. Information concerning the repartition between inorganic and organic P as well as the water-soluble or bicarbonate-soluble P forms in the fertilizers should be provided. I wonder why the sequential extraction was not performed on these products. A more detailed characterization of the applied material would help a more mechanistic interpretation of the results. Additional variables, such as dissolved and total organic carbon in these products, would help interpret the results. Dissolved organic compounds, for example, might displace some adsorbed phosphorus, thus increasing its availability. The Discussion Section "Large variability for soil P availability…" would greatly benefit and be less speculative if a more detailed characterization of the organic materials was performed.

Thanks. In this study, we choose poultry manure, cattle manure, maize straw, and bone meal as the renewable P-containing materials to conduct research. Poultry manure and cattle manure is widely used as renewable P-containing materials in current agricultural production. More importantly, the composition of manure P is affected by the digestive system difference between ruminants and non-ruminants, and the role of this difference in the subsequent P transformation process needs further study (Freiberg et al., 2020; Li et al., 2014). Meanwhile, straw turnover is usually applied directly to the soil in agricultural practice, and the P availability in straw requires in-depth analysis. The bone meal which can be recycled and used as a large amount of organic fertilizer in the future remains unclear in terms of P reuse (Ylivainio et al., 2008). We have supplemented the description of the organic materials in the Introduction.

As suggested, we analyzed all P-containing materials including total organic carbon and P fractions and other physicochemical properties before the start of incubation experiments. We have supplemented this detailed information in the modified manuscript. And we supplemented the discussion related to the P forms from raw materials.

3. The third point concerns the data analysis and other soil variables. The Olsen P and labile P fractions from the sequential extraction are correlated in the structural equation model because the P extracted with these two procedures is largely the same (L232-234 and L343-344). For this reason, it is confusing to state that the labile P fractions and the moderately labile P fractions had positive effects on soil Olsen P (L232-233) and other similar expressions. To provide a more mechanistic understanding using the SEM, it would be useful to include independent soil variables, such as clay content, iron oxides content, soluble organic carbon (which is expected to vary with the addition of organic material), which are all known to influence the sorption/desorption reactions of P in soils and therefore its availability.

Thanks for your suggestion. We attempted to better understand the contribution of different P fractions to the variation of soil Olsen-P concentration and the effects of environmental factors on P transformation by structural equation modeling. We have redescribed the SEM results in the modified manuscript.

It is also not clear which data were used to build the SEM, i.e. corresponding to which time points of the incubation.

Thanks. All data for the structural equation modeling were obtained from measurements on day 70 of incubation. We have supplemented this information in the modified manuscript.

Finally, language editing is needed, paying attention also to terminology. For example, the P fractions are most of the time called labile/moderately labile, etc., but sometimes the words “stable” or “active” or “inert” are used. This might create confusion, as these terms are not specifically defined. I suggest adopting consistent terminology throughout the manuscript. Another point: according to their NPK content, some of the organic products, ex maize straw, are technical amendments and not fertilizers.

Good suggestions. During the revision process, we have also done very careful language polishing accordingly. We carefully proofread the whole manuscript and standardized the terminology throughout the manuscript. In addition, we agreed with the reviewers' suggestion to define organic production as fertilizers are not strictly. We have modified the expression throughout the text accordingly.

Minor comments:

Please check throughout the manuscript the numbers after the decimal point in the percentages (sometimes zero, one or two numbers are shown, ex line 181, line 200, line 206) and homogenize to significant precision.

Thank you. We have improved this in the modified manuscript by homogenizing the number of decimal places in percentages to one digit throughout the manuscript.

L45-46: "the attendant environmental…" unclear formulation, please revise.

We have revised the sentence as follows: excessive application of phosphate fertilizer is a common phenomenon, which leads to soil P accumulation, water pollution, and crop quality decline.

L58: "it also affects" not clear what it refers to

Thanks. We have revised the sentence as follows: These renewable P-containing materials can also affect the P kinetics of the soil by changing the adsorption capacity of the soil to P.

L79-80: there are many papers published on the effect of renewable P-containing materials/amendments on soil P fractions (see the non-exhaustive list above). I suggest checking and integrating this literature into the introduction

Thanks for your suggestions. We have supplemented the introduction to the modified manuscript with a description of these research advances. And, the initial sentence has been modified as follows: Quantifying the transformations of different P-containing materials in soils with different soil conditions is necessary to enhance P utilization and reduce P resource limitation.

L109-112: other properties of the two soils such as the mineralogy or at least the texture

would be useful, as well as a classification of the soils such as according to the international World Reference Base (WRB)

We agree with these comments. We have supplemented the details of these two soils in the materials and methods, to provide a reference for the wider application of this study. The modified as follows: Soil samples were collected from fluvo-aquic soil (calcareous alluvial soil) in Hebei Province and red soil (ultisol) in Yunnan Province. The soil texture of fluvo-aquic soil is silt loam soil with 7.9% of clay (<2 μm), 55.3% of silt (2–20 μm), and 36.8% of sand (20–2,000 μm). The soil texture of red soil is clay with 47.5% of clay (<2 μm), 25.3% of silt (2–20 μm), and 27.2% of sand (20–2,000 μm).

L117: please, specify whether the P and K concentration in the products are given as P_2O_5 and K_2O or as P and K. It is always preferable to express them as P and K, see:

Thanks. The P, K concentrations of all P-containing materials are indicated by total P and total potassium. We have emphasized this in the Materials Methods section of the modified manuscript.

L127: please, specify to what the percent of soil moisture is referred to, e.g. water holding capacity or soil weight …

We have modified the sentence as follows: During the whole incubation stage, the gravimetric soil water content was kept at about 30% by soil weighing.

L122-123: what is the rationale for this quantity of P added?

The amount of P addition is based on the sufficient soil P amount of most crops to ensure the growth which is derived from the previous study (Kamran et al., 2019; Frazao et al., 2019). We have supplemented the modified manuscript with citations to relevant publications.

L143: “quantitation” is rather “quantification”?

This word has been modified accordingly.

L184: what are these ranges referred to? Are those the time points?

Data refer to the percentage increase in Olsen-P concentration in soils with CM compared to soils with other renewable P-containing materials. The description has been modified in the manuscript.

L190: “soil P fractions” instead of “fractionations”

Thank you. We have modified this in the manuscript.

L191-192 and L214: does the P added was completely recovered in the extracted fractions or not? This information is not easy to infer from table 2 or figure 3 but it would be useful to verify how much of the added P was not accounted for in the sequential extraction end ended up into non-extractable P.

Thank you for your suggestion. Except for the maize straw, all P-containing materials were well recovered during the measurements. We have supplemented the discussion of this result in the manuscript.

L225-226: “and more inositol… both soils” awkward formulation, please re-word

Thank you for pointing this out. We have revised the sentence as follows: Compared with other P-containing materials, the content of inositol hexakisphosphate in the two soils with PM increased significantly " in the modified manuscript.

L226 “supplemented both soils”, please reformulate

Thank you. We have revised the sentence as follows: Although the detected signals were weak, compared with SSP, more signals monoester P and inositol hexakisphosphate were detected in fluvo-aquic soil and red soil with PM and CM.

L269: what does “drab soil” means?

"drab soil" is a soil class according to the Chinese soil genetic classification, which corresponds to the Alfisols of the Soil Taxonomy, and here we follow the author's expression in the cited publication.

L279 “found rapid integration” please, reformulate this sentence

We have modified this in the manuscript.

L307-310: please refer to the supplementary figure showing pH values.

Thank you for your suggestions. We have supplemented the modified manuscript with a description of the changes of pH in soil with different P-containing materials.

L343-344: The P extracted with the Olsen extractant largely overlaps with the labile fractions of the sequential extraction. See also the third main point.

Thank you for your suggestion. We have redescribed the results of structural equation modeling in the modified manuscript.

Table 2: I am surprised by the very good precision of the measurements in some fractions, such as in the NaOH-Po, for which, in my experience, the variability usually is quite large. Are those analytical or real replicates?

We sieved all P-containing materials and soil through a 2 mm sieve before arranging the test and then mixed the soil with the P-containing materials thoroughly. And the samples were well mixed when collecting the samples. This was done to minimize errors caused by the uneven distribution of the samples. And, we strictly managed the environmental temperature and chromogenic time in the operation of the test. All samples were measured under the same conditions to minimize the effects of P transformation on the results during the extraction process. We believe that these results can be reproduced.

Not all the figures in supplementary materials are referenced in the text

Thank you for your suggestion. We have checked the whole manuscript in detail and supplemented the modified manuscript with a description of all the tables and figures in the supplementary materials.

References of response to referee comments

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