

Interactive comment on “Exogenous phosphorus compounds interact with nitrogen availability to regulate dynamics of soil inorganic phosphorus fractions in a meadow steppe” by Heyong Liu et al.

Anonymous Referee #1

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General comments

This study examined the effects of P compounds (KH_2PO_4 and $\text{Ca}(\text{H}_2\text{O}_4)_2$) with different addition rate on soil inorganic P (IP) fraction in a calcareous grassland. This study also set with and without N treatment and compare the effects of N addition on soil IP fraction. The design of this field fertilization experiments is appropriate and some results are fascinating. This study is also relevant to the scope of this journal. I thus think this study is novel and interesting and promote understanding about the phosphorus cycling in dry area. However, I have several concerns on this study and main 3 points are listed below. This paper can be accepted only after revision of this paper

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considering the comments. Especially for third points, authors must re-read through the manuscript and revise the relevant table, figure and description.

1. I wonder whether authors could extract Ca₂-P and Olsen-P properly. I agree that the potential limitation of the sequential extraction methods as described in p. 8. line 18-20 but I think that authors have to refer to the difference between Ca₂-P and Olsen-P in Introduction or Materials and methods. Although both of them are extracted with NaHCO₃, Ca₂-P is classified into moderate-cycling IP and Olsen-P into labile-P. Moreover, the concentration of Ca₂-P and Olsen-P in each treatment are really similar (Fig. 3 a,b and Fig. 5 a,b) and they are significantly positively correlated each other ($r= 0.63$ and 0.53 in Table 3). I wonder if authors extracted almost same chemical properties. Refer difference between Ca₂-P and Olsen-P in terms of chemical compounds. If they are chemically similar compounds, Ca₂-P should be eliminated from Moderate-cycling IP when SEM were built.

2. I have some concern about SEM. At first, how do the authors handle N addition effects when making SEM? There is no description about that. Second, the description “Moderate-cycling IP was mainly regulated by plant biomass” (e.g. p.2 line 14-15) sounds strange. In this study, plant biomass is also affected by soil IP. Finally, not only IP but Organic P also affects TP because the percentage of each IP fraction to total P (TP) is less than 50%. Organic P (TP-TIP) fraction accounts large part of TP and must have great effects on TP in this study. Author should explain these three points and reanalyze them.

3. I have serious concern about description in Results section of this study. This paper has several mistakes in the Results section. Some description in Results do not correspond to the relevant Table and Figure. Some specific comments are written below.

Specific comments

p.4 line 16-18: It may be appropriate to show which fraction of inorganic P increased in

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the previous study.

p. 6 line 4-7 (2nd hypothesis): I cannot understand how hypothesis 2 was derived. I particularly do not understand why authors hypothesized that recalcitrant P would be higher with KH_2PO_4 addition than with $\text{Ca}(\text{H}_2\text{PO}_4)_2$ addition. I think that it takes much time to form recalcitrant P from labile-P. Authors should add explanation about chemical properties of recalcitrant IP with introducing previous studies.

p.4 line 16-20: These two sentences introduce the previous studies which results were opposite. The connection of them is not good. I think that these two sentences should change to “Some previous study showed that ~~~ and other one showed that ~~~. ”

It may be appropriate to explain how large three species of plants (*Stipa baicalensis*, *Leymus chinensis* and *Carex duriuscula*) are occupied per area if authors have some data. Is there difference of dominant ratio among treatments?

p. 9 line 3-5 and p.10 line 11 and other: “P uptake” should be replaced by another word (i.e. the biomass-weighted P concentration). In this study, authors just determined the concentration of P in plant body not the P uptake.

Explain about dataset authors have. According to Materials and methods, authors used 110 plots in total including replication, which means that 0 kg P ha⁻¹ yr⁻¹ treatments are overlapped between KH_2PO_4 and $\text{Ca}(\text{H}_2\text{O}_4)_2$ fertilization. Although most of their data looks same among KH_2PO_4 and $\text{Ca}(\text{H}_2\text{O}_4)_2$ fertilization when 0 kg P were added but some are different. For example, soil pH is almost same between N treatment when 0 kg KH_2PO_4 were added (Fig. 1e) but there is difference between N treatment when 0 kg $\text{Ca}(\text{H}_2\text{O}_4)_2$ were added. Explain why some data are difference when 0 kg P were added as seen in soil pH.

p.10 line 21-23: Unclear, explain more in detail

Results 3.3 and 3.4: There are many faults. Relevant Figure and Table does not show the result which are written in manuscript. First of all, it is strange that there are two

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“3.3” section. Specific comments are below.

p.11 line 10-13: Fig 4a, b and Table S2 does not show the results as described in manuscript. I think authors should replace “0, 40, 100” by “20, 60, 80” according to Table S2. Moreover, Table S2 just shows whether there is difference of soil IP fraction between types of added P compounds (KH_2PO_4 and $\text{Ca}(\text{H}_2\text{PO}_4)_2$) or not but it does not show which is higher or lower between them.

However, Table S2 does not coincide with Fig.4a and b. For example, Table S2 shows that soil Ca10-P are significantly different (Student t-test, $p < 0.01$) between KH_2PO_4 and $\text{Ca}(\text{H}_2\text{PO}_4)_2$ addition when 0 kg P were added but they look no different in Fig 4a and b. I think something is wrong and authors should reconfirm the dataset and reanalyze them.

p.11 line 14-16: There is no asterisk in Fig. 4d. I cannot judge whether there is significant difference between Without N and N addition at 60 and 80 kg P $\text{ha}^{-1} \text{yr}^{-1}$.

p.11 line 18-20: Unclear, explain more in detail. What about O-P for 0 kg P $\text{ha}^{-1} \text{yr}^{-1}$ treatment with N addition? Table S2 shows the significant difference between KH_2PO_4 and $\text{Ca}(\text{H}_2\text{PO}_4)_2$ addition ($p < 0.05$).

p.12 line 3-4: Fig. 5d does not show that results. Soil TP with $\text{Ca}(\text{H}_2\text{PO}_4)_2$ does not increase with increasing P addition when N was added.

p.12 line 7-8: There are no results which indicate correlation between TP and moderate-inorganic IP (Fe-P, Al-P, Ca2-P, Ca8-P) in Table 3.

p.13 line 1: “applied P was immobilized mainly into inorganic forms” sounds strange. “Immobilization” is the conversion of inorganic materials to organic ones.

Add “soil” before each P fraction. Some are already added but I think that authors should unify the expression about soil IP fraction.

Is the term “recalcitrant inorganic phosphorus” used commonly?

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p.15 line 13: not “P demand” but “concentration of P in plant” as pointed out above.

p. 15 line 3-6: The sentence is wordy.

Conclusion: I think that authors should suggest how to fertilize P and N appropriately on grassland ecosystems to maintain plant productivity in Conclusion based on the results of this study.

Technical corrections

p.3 line 17 and other: Olsen P => Olsen-P

p.4 line17: inorganic P => IP

p.7 line 1: phosphorus => P

Caption of Fig. 7: moderate-cycling P => moderate-cycling IP

Fig. 4c: Replace lowercase letters (i.e. a, b) by capital letters (i.e. A, B).

Fig. 5a: The vertical axis labels of Fig. 3a and c and the horizontal axis labels of Fig. 5a are written in bold type and they should be changed.

Fig. 6: Explain what the width of arrows means.

Fig. S1 and 2: Replace “N0” and “N10” by “Without N” and “N addition.” The terms “N0” and “N10” are not used in the main manuscript.

I recommend that authors use consistent color for “Without N” and “N addition” in figures for easy understand. In current manuscript, white bar represents “Without N” in the bar graph, whereas white dot represents “N addition” in the scatter plots. Red fitted line represents “Without N” in Fig. 1c, d and “N addition” in Fig. 2, 3.

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