## **KEY:**

Editor/Reviewer Comments
Author Response
Already in Text
Modified Text
**Comments from Reviewer**

**First Review/Response ()**

Associate Editor: 1

Comments to the Author:

First, I would like to thank the authors for their thorough editing and reviewing of the reviewer and AE comments. Second, I would like to thank the authors for their patience during this review process.

For this round of edit/comments, I highlighted specific words, phrases, sentences or parts of paragraphs that need clarification for the reader.

Abstract. Need a concluding sentence. What does it all mean?

Again, thank you for your comprehensive review that has significantly improved our work.

Our final sentence delineating an estimated PUE for the world has been consistent over the three reviews. We believe that this finding (16% PUE using the difference method) is by itself important.

P4, L81-88: This paragraph starts with a lead sentence about the significance of P fertilizers, but the rest of the paragraph is a review of known NUE. In the context of the entire intro, the sentences about NUE seem out of place. I would suggest that the authors provide more context to their relevance with PUE or delete.

Good point. This has been clarified, and the value of having a PUE estimate consistent with the world NUE value that was already estimated.

P4/L89: The first two sentences need a transition between them. One suggestion would be to combine them into one sentence with “, although Syers (2008) has provided…”

Change made

P5/L91: I don’t think “encumbered” is the right word here. Also, since you are starting with the definitions, it seems out of place to start comparing the methods to each other without first reviewing what the methods/calculations are.

Encumbered changed to includes. We agree that this is a cumbersome sentence, but keeping the Johnston and Syers (2009) findings together seemed to us to better way to communicate their value.

 P5/L96: change “and that was used” to “using”

Change made

P5/L100-101: The Johnson and Syers (2009) reference here is confusing. Are they using a different calculation compared to Syers (2008)? Also, here the authors state “to compute P fertilizer recovery.” I think semantics matter a great deal for this publication, as slightly different phrasing can imply different things. P fertilizer recovery is really only measured through a difference method or use of isotope tracer to get at how much applied P was recovered in the plant.

Methods used in the 2008 and 2009 papers were the same. The 2009 Johnston and Syers paper specifically used “recovery” and why we did as well. We understand your point on the use of 32P.

\*It is at this point, a reader may ask why the authors are not considering utilization efficiency (i.e. the amount of P taken up by the whole plant). Surely that would improve the “efficiency” numbers. Or even the amount of P that is applied that is taken up by the plant in some way, even though it is not removed from the system. Perhaps this can be addressed by the authors before or after the statement of objectives by indicating why they are measuring PUE. To get at what exactly? I think then the authors could provide a nice concluding statement in the abstract as well. Also, this manuscript has, what amounts to, a short review on strategies to improve PUE. This needs to be acknowledged in the objectives. The objectives of this study/paper were to calculate PUE, but then to also review opportunities for PUE improvement.

Your point is a good one. Our focus has and continues to be on providing a world estimate of PUE. Methods to improve PUE have been addressed in the manuscript, and are included below. As per your comment, the abstract has been modified accordingly. Also, this has now been included in the conclusion.

Faulkner, S. 1999. Foliar feeding when your plants need it fast. In: The Growing Edge. New Moon Publishing. Corvallis, Ore. 42-47.

Hussein, A. 2009. Phosphorus use efficiency by two varieties of corn at different phosphorus fertilizer application rates. Res. J. Appl. Sci. 4: 85-93.

Maleki, M.R., A.M. Mouazen, B. De Ketelaere, H. Ramon, and J. De Baerdemaeker. 2008. On-the-go variable-rate phosphorus fertilisation based on a visible and near-infrared soil sensor. Biosys. Eng. 99:35-46.

Mallarino, A.P., and D.J. Wittry. 2006. Variable-rate application for phosphorus and potassium: Impacts on yield and nutrient management. Integrated Crop Manage. Conf. :219-224.

McBeath, T. M., M. J. McLaughlin, R. D. Armstrong, M. Bell, M. D. A. Bolland, M. K. Conyers, R. E. Holloway, and S. D. Mason.2007. Predicting the response of wheat (Triticum aestivum L.) to liquid and granular phosphorus fertilisers in Australian soils. Aust. J. Soil Res.45: 448-458

Mosali, J., K. Desta, R.K. Teal, K. W. Freeman,K.L. Martin, J.W. Lawles, and W.R. Raun, 2006. Effect of foliar application of phosphorus on winter wheat grain yield, phosphorus uptake, and use efficiency. J. Plant Nutr. 29:2147-2163.

Peterson, G., D. Sander, P. Grabouski, and M. Hooker. 1981. A new look at row and broadcast phosphate recommendations for winter wheat. Agron. J 73:13-17.

Schepers, J.S., M.R. Schlemmer, and R.B. Ferguson. 2000. Site-specific considerations for managing phosphorus. J. Env. Qual. 29:1, 125-130.

Wittry, D.J., and A.P. Mallarino. 2004. Comparison of uniform- and variable-rate phosphorus fertilization for corn–soybean rotations. Agron. J. 96:26-33.

P6/L122 (the PUEd) equation: the phrase “P removed from the soil” is not clear here. The P removed from the soil can be thought of as the change in soil test P or the difference in total P uptake between fertilized and unfertilized. But here it just means the P removed in the grain coming from the soil. So, the PUEd, as is, is a functional definition, but not an equation anyone would actually use to calculate PUEd in any one study, as a study with the difference method would subtract “P in grain from control plots” and 32P studies would use a calculation that is a direct measure of how much fertilizer P is in the grain. Also, there doesn’t seem to be any explanation about the nature of the individual studies (difference or direct). The subsequent discussion here is about Table 2, which is really part of the M&M, as it is the authors approach to getting at one value to correct PUE-B to PUE-D.

Your point notes the importance of Table 2, where P removed from the soil was estimated. This was in M&M and that we moved to the Introduction, following the second review. The equations were all in M&M and for the very reason that you point out. The last review did require significant restructuring that is now being questioned. We request to move forward with the current format, coming from the last review.

P6/L130: “Estimates of cereal PUE” can’t “recognize”. Also, a term like “residual” effects need to be explained. This is a very important part of this paper and needs to be defined more thoroughly. This entire sentence should be edited for clarity.

This sentence has been modified and an explanation of ‘residual P’ included.

P7/L148 (and 156): Is the term “consumed” correct here? I would argue that the cropping system (plant and soil) consume the P, but no the crop. This term would also suggest that the P applied is consumed by the plant (uptake).

References to consumed have been changed to ‘taken up.’

Table 3. The mean of the PUE-D, appears to be 20.7% of PUE-B. But this is not correct based on your equations. Following the “values and computation column”, the mean PUE-B should be 5,999,998 / 7,826,122, which should equal 76.7%, but is reported as 79%.

You are correct and this was our mistake. Correction made.

For variable H, the value should be 0.793 X 5,998,998 which should be 4,757,998, but is listed as a different value.

Also incorrect on our part and corrected accordingly

i.e. something is wrong with the math in Table 3.

Thank you for reviewing this entire Table. Our mistake/now corrected

P8/L161: I think you need to keep “of all cereal crops” because it is not clear otherwise what average you are referring to.

A previous review had us delete this, but it has now been added back.

P9/L185: In SAS, proc is short for procedure; this sentence should be rephrased to reduce redundancy.

Correction made

P9/L190 (and elsewhere): This may be my editorial preference, but I am reading this in 2017 and the data in Figure 1 do not represent that last 53 years. I would suggest keeping in context of the years analyzed.

This has been changed to address your comment.

Over a 53 year period, (1961-2013, Figure 1),

P9/L191: The sentence about Tiessen et al. 2011 is out of place. What is the context. It is not clear if this reference agrees or contrasts with the first sentence.

This reference has been moved to the conclusions, where it more accurately conveys world P importance

P10/L210: The average was stated for PUE-D, but not here for PUE-B. The authors have gone to a lot of trouble to report the summary statistics in Table 3, but only report the overall mean of PUEd in the text.

Average values for PUE-B were added to this paragraph

P11/L227-230: This is not clear. What future years are the authors referring to? Beyond 2013?

This has been clarified to “In years that follow.”

P11/L233: Start the sentence with “The”

Change made

P11/L237: delete “from work”

Change made

P11/L240: Is 79% low?

This sentence was changed so as not to include an overarching statement for method.

P13/L294: While Syers et al. (2008) may have referenced adjusting base saturation, I think you will need to find a more specific reference for this. To me this doesn’t make any sense.

This statement is applied soil chemistry.

P15/L331: This paragraph seems like it would be better as part of the previous one as the paragraph 326-330 is not a stand alone paragraph.

Paragraphs joined

P15/L340-343: What does a 1 m level mean in context of a field? Each soil sample should be within 1 m of each other? Or sampled on a 1m2 basis?

1m2 resolution added, referencing their work

P16/L349: The first sentence of the conclusions is about P deficiency, which wasn’t addressed at all in this paper.

Deficiencies as a function of soil orders was included (Brady and Weil 2008). Deficiencies of P remain important for work that highlights use efficiency.

P16/L351: It is obvious that better management will improve PUE. If they didn’t, they would be better practices. This is a circular argument.

Sentence modified

Also, it seems odd to have the beginning of the conclusions talk about how to improve PUE and then close with stating what the PUEs are.

Some of this has been restructured. Main finding remains at the end.