We thank the reviewer for their critical assessment and will provide a revised manuscript addressing the reviewer's comments. Throughout the following document, the reviewer's comment is stated first, followed by our response in *italic* font.

Comment on bg-2021-217
Anonymous Referee #2

Referee comment on "Water uptake patterns of pea and barley responded to drought but not to cropping systems" by Qing Sun et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-217-RC2, 2022

General comments: Adaptive crop management is a potentially important strategy to mitigate crop failures due to climate-change induced drought stress. How plants utilize water across different cropping systems could determine the extent to which a particular management system can be used to mitigate plant drought stress. The authors argue that very few studies have evaluated plant water uptake patterns in response to drought in arable cropping systems. The manuscript is generally well written, and I have mostly minor suggestions for improving clarity in a few places.

- *Thank you very much for this very positive evaluation.*

(1) My one main concern about the study is that it simulates a very short-term drought during a natural drought, such that moisture conditions in the drought treatments were not that different from control plots. The authors should provide a stronger rationale for why the results of such a short-term study are relevant. (2) That is, why would differences between cropping systems be expected given the experimental design and natural drought conditions during the study period? (3) The authors should also discuss if/why one year of data collection is sufficient, especially given that a natural drought occurred during the study period. Are there data available from previous or subsequent years that could be brought to bear on these questions? For example, are there data on root biomass that could be included to strengthen the paper? (4) I would also like to see acknowlegment and discussion of the role of mycorrhizal fungi on drought responses.

- *Thank you very much for the comments. We added numbers (1-4) in the above comment to facilitate evaluation of our answers.*
- *(1) Regarding the length/severity of our drought treatment: Our simulated drought was not very short but actually 5 weeks long. Compared to our local climate conditions, and on the background of studying an annual crop species with a rather short growing phase, a 5-week drought is quite severe. This can also be seen in Fig. 1, where 5 weeks without precipitation were absent in 2018. We excluded 34% of the precipitation during the growing season, as given in Tab. 1, The scenarios for Switzerland (i.e., CH2018, https://www.meteoswiss.admin.ch/home/latest-news/news/climate-scenarios-ch2018.html; page 6) foresee a reduction up to 25% in precipitation in Switzerland in 2060 due to climate change, up to 40% by the end of the century. Our reduction for 2018 was right in the middle of these two numbers. In addition, the CH2018 scenarios foresee an increase of the longest rain-free summer period (June, July, August) from currently 11 days to 20 days, even shorter than our 5-week drought simulation. Thus, both length and severity of our treatment were very strong, clearly strong enough to simulate a future drought scenario threatening food security. We will add this information in the revised version.*

- *(2) Regarding the natural drought: The natural drought 2018 occurred end of June, at the end of our experimental drought treatment (see Figs. 1 and 2), when the plants had already received about 150 mm of rain (see Tab. 1) and most likely also developed their main rooting system according to non-drought conditions. We expected differences among cropping systems because the Farming Systems and Tillage Experiment was established in 2009, i.e., the cropping systems were already in place 9 years before our drought study took place. It has been reported that these cropping systems in our site resulted in different soil properties (see Wittwer et al., 2021). Wittwer RA, Bender SF, Hartman K, Hydbom S, Lima RAA, Loaiza V, Nemecek T, Oehl F, Olsson PA, Petchey O, et al. 2021. Organic and conservation agriculture promote ecosystem multifunctionality. Science Advances 7(34).*

- *(3) Regarding the number of study years, we think this one year of experiment with an intensive sampling and measurement campaign is sufficient to show the response of a short-term crop like pea and barley and their water uptake to drought and the lack of cropping systems effects.*
    - *Our experimental design included drought and control sub-plots. Thus, we worked with replicated subplots in parallel (i.e., at the same time), not after each other (i.e., a temporal replication over multiple years). Since we were interested in the response of pea and barley to our drought treatment and not in their long-term yields, we think that our experiment design is adequate.*
    - *In addition, in croplands, the identical crop should not be grown on the same field for several years due to arising soil health issues. This is the reason why agriculture in many countries works with rather elaborate crop rotation schemes, not only in Switzerland. Our study is no exception in this respect, a 6-yr rotation is used on this site and this rotation never has two legume crops following each other. So, it would not have been possible to again grow pea-barley in the following years on the same plots.*
    - *The increasing competition/lack of niche differentiation observed between pea and barley grown in a mixture under the drought treatment within the usual cropping season was surprising and deserves attention since farmers need to know about such an undesired outcome.*
    - *Besides, the natural drought was not a disruption for the experiment. On the contrary, with the natural drought (in control subplots, occurring at the end of the drought treatment) and the simulated drought (in drought subplots), we could study an aggravated drought scenario, one that is becoming more likely in the future.*
- *(4) Regarding mycorrhizal fungi: We agree that mycorrhization is worth mentioning as one of the reasons that can cause different plant water uptake patterns in cropping systems. Some studies discussed the positive effects of organic management and possibly from conservation tillage, maybe modulated via mycorrhizal fungi. Therefore, we will address this aspect in the introduction. Our results clearly showed no interactions between cropping systems and the simulated drought; and the potential benefits from soil as affected by different management practices were not able to overcome the drought effects (L399-409). So we will also address mycorrhizal activities as part of those soil functions that were overwhelmed by the simulated drought.*

Commented [KV1]: Does this still refer to (3)? I feel the arguments before are sufficient and fit better to what the reviewer asks

Commented [SQ2R1]: It’s about the “especially there was a natural drought..”

Specific comments:

L13-17. Some of the Highlights bullets are unclear as written

- *Thank you for the comments. We guess that the lack of "was" or "were" created this impression. We will rephrase.*

L22-23. Which species is the important "fodder crop" or is it the mixture that is the "crop".

- *The 'pea-barley mixture' as an intercrop is the important fodder crop. We will clarify this in a revised version.*

L29-30. Check sentence construction.

- *We will revise it as "Both species showed similar responses to the drought simulation and increased their proportional* ***water uptake*** *from shallow soil layer (0-20 cm) in all cropping systems."*

L42. "Adapted" should read "Adaptive"

- *Thank you for the suggestion.*

L63-70. Root-mycorrhizal interactions are also presumably important, but are not discussed here (and should be)

- *Thank you for the suggestion. We will include references discussing the potential benefits on mycorrhiza in organic systems. See also response (4) above.*

L80-81. As opposed to when grown alone?

- *No, this is a misunderstanding. Just to compare the two species in the mixture. We will check and improve the sentence when revising the document.*

L111-112. What are typical rainfall patterns during this period? Is a one-month drought during this time atypical? This seems like a fairly short period of drought conditions. Also, what was the antecedent conditions in the months preceding the drought period. If rainfall was at or above average, perhaps a one month drought is not a problem? If I'm interpreting Table 1 correctly, it actually looks like precipitation in the control plots was ~30% of normal, so it appears there was a natural drought during the imposed drought period. I wonder why water wasn't added to control plots to simulate a "normal" year.

- *Thank you for the questions.*
    - *Our study did not aim at an atypical or typical drought, but at a prolonged drought as predicted under climate change; the drought treatment was more than a month (37 d) and is therefore substantial for a three-and-a-half-month growing season for our pea-barley mixture. Currently, the longest period of no rain during summer is 11 days. Our 37-day drought is therefore quite long.*
    - *Indeed, there was a natural drought, which was also addressed in discussion (L361-366) and can be seen in Tab. 1 as well as in Figs 1 and 2. In Tab. 1, one can also see that May precipitation was similar to the long-term mean (102 vs 105 mm). So no water surplus or scarcity before our drought treatment. We will describe Tab. 1 better in the MatMet section to avoid any misunderstanding here.*
    - *We did not irrigate the control subplot during the natural drought for different reasons: (i) We did not want to simulate a "normal" year vs. a drought period, but add the drought stress on*

top of the actual rainfed conditions. Also because irrigation is no typical agricultural measure in this region and the natural drought was not extraordinary strong so that it would have caused substation yield losses. (ii) We clearly did not anticipate such a natural drought during our experiment. Adding irrigation short-term was beyond our logistic possibilities and irrigating the control subplots with tap water (since no rainwater could have been collected during the natural drought) would have added nutrients to the controls and thus would have altered soil chemistry. This would have destroyed our experimental design.

L123-128. Describe antecedent moisture conditions here (i.e., per my questions above).

- *Thank you for the suggestion. However, we do not fully understand what is requested here in addition to what we already provide. In Tab. 1, we give the long-term climatic conditions as well as those during the growing season 2018 and separate months. In Figs 1 and 2 we show the temperature and the precipitation during the entire year 2018 (precipitation; Fig. 1) and during our experiment (soil moisture; Fig. 2). So we think we have covered the antecedent moisture conditions already.*

L322-325. I don't understand this response. Under drought, when the surface soil is presumably dryer, wouldn't plants tend to have deeper rooting depths and/or obtain more water from depth?

- *Thank you for the question. Indeed, this question is what the Bayesian mixing models are used for, based on the stable water isotope data. While deeper rooting in response to drought is the usual assumption, experiments and observations do not always show such reliance on deeper soil layers during drought. We discussed such results in comparison to ours in detail in discussion (L326-341 and L342-360).*

L415. "adaptive" not "adapted"

- *Thank you for the correction. We will change the word accordingly.*

L415-417. I would take some care with this conclusion, acknowleding that cropping system differences may be more pronounced under longer-term drought (see previous comments above)

- *Thank you for the suggestion. As you have pointed out above, in addition to our drought treatment, there was a natural drought (leading to only 40% of monthly precipitation in June 2018 compared to long-term average in June under rainfed conditions). Our 37-d drought treatment simulated a much more severe drought than the natural drought (excluding 79 mm). Altogether, we report data of a "more pronounced drought". Still, we did not find significant differences in changing water uptake patterns among the different cropping systems. We consider our results sufficient to conclude that under future climate with similarly small water supply, cropping systems might not be reliable to provide consistent alleviation for plant drought stress for pea-barley. But as also written, it remains to be seen how other crops react.*

Table 1. It unclear what the last three lines in the table refer to. Are these precipitation amounts in the drought treatment itself?

- *Almost. As indicated in the first column, the values are total precipitation and mean air temperature during the respective time periods separated by the drought treatment. Therefore, not just in the drought treatment itself, but before, during, and after the drought treatment. We will revise the second last cell (change "End of drought treatment" to "During drought treatment").*

Table 2-5. I assume the values shown are P-values, but that is not explicilty stated in the table heading. This is a lot of tables of p values...

- *Thank you for the comment. Yes, they are p values. We will revise the captions to clarify the values.*

L671-674. I'm unclear why these lines are shown below the table. Is this text part of the heading or a footnote to the table?

- *It serves as a footnote to the table.*