**General comments**

The paper by He et al. aimed to disentangle the degree and depth limitation of deep soil desiccation and its impact on tree's xylem hydraulic conductivity based on the published and sampled data from China's Loess Plateau. They argued that the degree limitation approached the permanent wilting point (PWP) and hence the PWP can be used to indicate the lower limit of root water uptake by different tree species. The depth limitation was also identified and varied between tree species and regions. Furthermore, they also reported that the loss of hydraulic conductivity was as high as 74.9-96.5% when both limitation were reached.

Overall, this paper is well motivated and mostly well structured and written. According to my knowledge, the research topic is less studies in the existing literature. The first conclusion seems not surprising that PWP is a good indicator of the degree limitation of deep-layer soil moisture (DSM) for the tree species examined because it is often used in this way. But I think this conclusion is interesting since PWP is usually determined using annual crops and more important, in that the deep-layer soil moisture reached the degree limitation while the shallow-layer soil moisture did not. Although this study has scientific merit and can be a scientific contribution potentially, I still have two major concerns about the method and discussion. (1) My first concern is about the definition of deep soil moisture deficit (DSMD). In this definition, they mentioned background soil moisture. The authors should clarify what does background soil moisture mean here, and why the DSM in adjacent control can reflect local annual precipitation. Moreover, in my opinion, the definition of DSMD should be moved to the method part. (2) The other concern is the discussion of the effect of limitation on xylem hydraulic conductivity. The discussion in this part seems not thorough and should be rewritten to improve the relevance.

**Response:** Thanks for your time and constructive comments on our paper.

About your first concern, our explanation is given as follow. The deep-layer soil moisture (DSM) under planted trees with the same age can vary greatly in different

sampling years if these years have very different annual precipitation. In order to eliminate the effect of varying annual precipitation on DSM, “deep soil moisture deficit (DSMD)” is defined as the relative difference of DSM under given trees and nearby grassland or cropland. In grassland/cropland, the rooting depth of plants is relatively shallow (<2 m) and hence does not influence DSM below 2 m (Gao et al., 2014; Zhu et al., 2016; Gao et al., 2022). Therefore, the magnitude of DSM in grassland/cropland is mainly determined by annual precipitation. In this way, it can be used to reflect local annual precipitation; i.e., the greater DSM in grassland/cropland, the bigger annual precipitation. Finally, the DSM in grassland/cropland is termed as background soil moisture here because it is not influenced by plants and can reflect local annual precipitation. In addition, the definition of DSMD will be moved to the method part in the revised manuscript (Lines 229-233).

References:

Gao, X., Wu, P., Zhao, X., Wang, J., Shi, Y.: Effects of land use on soil moisture variations in a semi-arid catchment: Implications for land and agricultural water management, Land Degrad. Develop., 25, 163-172, 10.1002/ldr.1156, 2014.

Zhu, G., Deng, L., Zhang, X., Shangguan, Z.: Effects of grazing exclusion on plant community and soil physicochemical properties in a desert steppe on the Loess Plateau, China, Ecol. Eng., 90, 372-381, 10.1016/j.ecoleng.2016.02.001, 2016.

Gao, X., He, N., Jia, R., Hu, P., Zhao, X.: Redesign of dryland apple orchards by intercropping the bioenergy crop canola (*Brassica napus* L.): Achieving sustainable intensification, Glob. Change Biol. Bioenergy, 14, 378-392, https://doi.org/10.1111/gcbb.12916, 2022.

**(2)** Thanks for your suggestion. We will rewrite the part about the effect of degree and depth limitations on xylem hydraulic conductivity as follows in the text (Lines 399-414).

“The result showed that branches xylem of similar aged trees suffered embolism to

different degrees when the DSM reached degree and depth limitation (Fig. 7). This is consistent with the hypothesis that the hydraulic conductivity of planted trees can be greatly reduced by severe deep soil desiccation. The reason for this result is that dried soil seriously restricts the process of root water uptake, and water absorption of trees is difficult to meet the needs of aboveground metabolism, resulting in the interruption of the water column in the xylem vessels during prolonged dry periods, and thus *PLC* increases (McDowell et al., 2018; Yang et al., 2022). Subsequently, the leaf stomata close to prevent hydraulic failure as DSM approaches PWP. How long can the planted trees survive after this depends solely on the water pools of themselves and their tissues' tolerance for drought stress (McDowell et al., 2022). Nevertheless, even though DSM of all regions both have been close to the local PWP, *PLC* varied greatly between different climate zones (Fig. 7), mainly caused by the difference of precipitation about time and amount for restoring shallow soil moisture. This suggests that the decrease in xylem hydraulic conductivity caused by the limitation of DSM may be repaired after entering the rainy season for the studied species plantations in Changwu and Yan'an. The *PLC* of black locust plantation in Mizhi, however, was significantly ($p$<0.05) higher than that of other regions, and restoration of embolism was more difficult due to limited rainfall supply. Thus, the embolism in the conduit accumulated continuously as the water pool became exhaustible causing the top tip of the distal water supply began to die due to hydraulic failure of tissues (Fig. S3; Arend et al., 2021). This indicates that mature (>24 year) plantations on the LOP are already facing a great risk of dieback and even death in semi-arid regions similar to Mizhi."

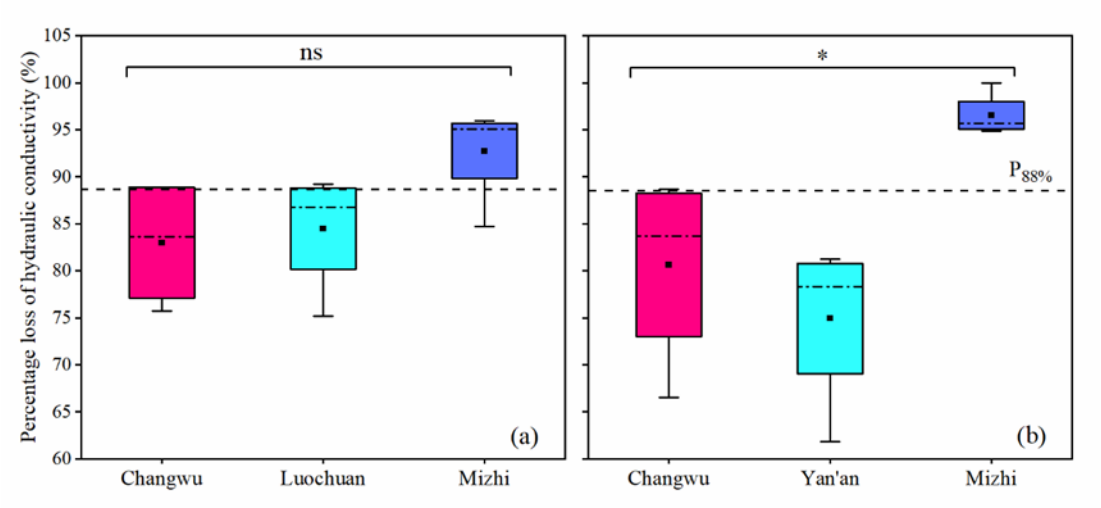


**Figure 7:** Differences in percentage loss of hydraulic conductivity of annual branches of apple (a) and black locust (b) in different regions (Changwu, Luochuan, Yan'an, and Mizhi). * or ns indicate that the significance level is $p<0.05$ or there is no significant difference, respectively.

**Figure S3**. Dieback of black locust (*Robinia pseudoacacia* L.) plantation in Mizhi.

## References:

Arend, M., Link, R.M., Patthey, R., Hoch, G., Schuldt, B., and Kahmen, A.: Rapid hydraulic collapse as cause of drought-induced mortality in conifers, PNAS, 118(16), 10.1073/pnas.2025251118, 2021.

McDowell, N., Allen, C.D., Anderson-Teixeira, K., Brando, P., Brienen, R., Chambers, J., Christoffersen, B., Davies, S., Doughty, C., Duque, A., Espirito-Santo, F., Fisher, R., Fontes, C.G., Galbraith, D., and Goodsman, D.: Drivers and mechanisms of tree mortality in moist tropical forests, New Phytol., 219 (3), 851-869, 10.1111/nph.15027, 2018.

McDowell, N.G., Sapes, G., Pivovaroff, A., Adams, H.D., Allen, C.D., Anderegg, W.R.L., Arend, M., Breshears, D.D., Brodribb, T., Choat, B., Cochard, H., et al.: Mechanisms of woody-plant mortality under rising drought, $CO_2$ and vapour pressure deficit, Nat. Rev. Earth Env., 3(5), 294-308, 10.1038/s43017-022-00272-1, 2022.

Yang, M., Gao, X., Wang, S., and Zhao, X.: Quantifying the importance of deep root water uptake for apple trees' hydrological and physiological performance in drylands, J. Hydrol., 606 (11), 127471, 10.1016/j.jhydrol.2022.127471, 2022.

The specific comments are given as follows.

**Abstract**

Line 20: Why use DSMD for analysis here?

**Response:** The deep-layer soil moisture (DSM) under planted trees with the same age can vary greatly in different sampling years if these years have very different annual precipitation. In order to eliminate the effect of varying annual precipitation on DSM, "deep soil moisture deficit (DSMD)" is defined as the relative difference of DSM under given trees and nearby grassland or cropland. In grassland/cropland, the rooting depth of plants is relatively shallow (<2 m) and hence does not influence DSM below 2 m (Gao et al., 2014; Zhu et al., 2016; Gao et al., 2022). Therefore, the magnitude of DSM in grassland/cropland is mainly determined by annual precipitation.

References:

Gao, X., Wu, P., Zhao, X., Wang, J., Shi, Y.: Effects of land use on soil moisture variations in a semi-arid catchment: Implications for land and agricultural water management, Land Degrad. Develop., 25, 163-172, 10.1002/ldr.1156, 2014.

Zhu, G., Deng, L., Zhang, X., Shangguan, Z.: Effects of grazing exclusion on plant community and soil physicochemical properties in a desert steppe on the Loess Plateau, China, Ecol. Eng., 90, 372-381, 10.1016/j.ecoleng.2016.02.001, 2016.

Gao, X., He, N., Jia, R., Hu, P., Zhao, X.: Redesign of dryland apple orchards by intercropping the bioenergy crop canola (*Brassica napus* L.):

Achieving sustainable intensification, Glob. Change Biol. Bioenergy, 14, 378-392, https://doi.org/10.1111/gcbb.12916, 2022.

Line 30: Do you have observational evidence of tree mortality in the study site?

**Response:** Yes, we observed mortal trees during sampling. The photos that showing tree dieback in the study site were given as Figure S3 above, and it will be added in the supplemental file of the revised manuscript.

**Introduction**

Line 35: The range of loess thickness is often used as 30-200 m in the literature.

**Response:** We agree. It will be corrected as "30-200 m" in the text (Line 35).

Line 38: The citation in many parts is not mostly relevant. For instance, the citation of Gao et al., 2021 did not study the three-north shelter forest program.

**Response:** Thanks for your suggestion. The citation of "Gao et al., 2021" will be changed to "Cao et al., 2021" in the text (Line 38).

Reference:

Cao, S., Xia, C., Suo, X., Wei Z.: A framework for calculating the net benefits of ecological restoration programs in China, Ecosyst. Serv., 50, 101325, 10.1016/j.ecoser.2021.101325, 2021.

Line 66: Several earlier studies have reported the dwarf aged trees. There studies should be cited here.

**Response:** Thanks for your comment. Zhu (2000) and Hou et al. (1991) also mentioned the dwarf aged trees, so we will cite the two references in the revised manuscript (Lines 66-67).

References:

Hou, Q., Huang X., Han, S., Zhang, X.: The status of soil moistures and nutrients in small-old-tree stands and impact on tree growth (In Chinese), 5(2), 75-83, Journal

of Soil Water Conservation, 10.13870/j.cnki.stbcxb.1991.02.012, 1991.

Zhu, X.: Rescue the “soil reservoir” to control the ecological environment of the Loess Plateau (In Chinese), Bulletin of Chinese Academy of Sciences, 2000(04), 293-295, 10.16418/j.issn.1000-3045.2000.04.019, 2000.

Lines 70-71: This sentence is not clear and should be rewritten for clarity.

**Response:** This sentence will be rewrite as follows in the text (Lines 70-72).

“They found that the canopy transpiration and the net photosynthetic rate of apple trees without deep-layer root water uptake was reduced, respectively, by 36% and 20% on average, compared with the trees with deep roots in a semiarid site on the LOP.”

Line 78: change disentangle to explore

**Response:** We agree. It will be edited in the text (Line 81).

Line 81: Does any literature support this statement about the difference of drought-resistance capacity between tree species?

**Response:** Yes. Gessler et al. (2020) reported individuals have different abilities to persist and maintain their functions during drought to support this statement. This reference will be cited in here (Line 83).

Reference:

Gessler, A., Bottero, A., Marshall, J., Arend M.: The way back: recovery of trees from drought and its implication for acclimation, New Phytol., 228(6), 1704-1709, 10.1111/nph.16703, 2020.

**Materials and methods.**

Line 86: Why does the literature begin in 1999?

**Response:** This is because the ecological project of the Grain-For-Green Program started in 1999. Thereafter, trees were planted extensively and intensively on the Loess

Plateau.

Line 99: Why were only apple tree and black locust used for analysis?

**Response:** In the Grain-For-Green Program, trees of both ecological and economic objectives were planted extensively. The black locust is the most planted trees for ecological objective, while apple tree is the most planted trees for economic objective (Gao et al., 2021). Furthermore, these two tree species are the most studies and reported in the literature. Therefore, these two tree species are used for analyses because of they are mostly representative in the literature.

Reference:

Gao, X., Zhao, X., Wu, P., Yang, M., Ye, M., Tian, L., Zou Y., Wu Y., Zhang F., and Siddique K. H. M.: The economic-environmental trade-off of growing apple trees in the drylands of China: A conceptual framework for sustainable intensification, J. Clean. Prod., 296 (3), 126497, 10.1016/j.jclepro.2021.126497, 2021.

Line 130: Please give the full name.

**Response:** We agree. The full name of GPS is Global Positioning System. It will be edited in the text (Line 135).

Line 136: How do you judge whether the DSM reaches the degree limitation during sampling?

**Response:** In the soil sampling, soil moisture in the 0-10 m was measured gravimetrically under the selected tree age plantation as well as the control farmland/grassland. Then, the relative soil moisture (i.e., deep soil moisture deficit (DSMD)) was calculated to determine whether the DSM reached the degree limitation. If yes, soil moisture was continuously measured in the 10-25 m.

Line 142: Soil moisture can be varied clearly at different directions around a tree. How do you address this issue?

**Response:** In the sampling, we chose three trees with same age and similar growth

status as three replicates, in order to diminish the difference in soil moisture. In order to reduce the effect of directions on soil moisture, the samples were collected at different direction for the three replicated trees. Here are the details. We collected soil samples in the due north direction of the first tree, a clockwise rotation of 120° around the second tree from the due north direction was used as the second sampling point, and a clockwise rotation of 240° around the third tree from the due north direction was used as the third sampling point, all replicates were located 1.5 m away from the trunk. To eliminate the effect of different sampling directions on the results, the soil water of the three trees were averaged for analyzing. The text will be edited as follows for clarity in the revised manuscript (Lines 148-152).

"Collecting soil samples in the due north direction of the first tree, a clockwise rotation of 120° around the second tree from the due north direction was used as the second sampling point, and a clockwise rotation of 240° around the third tree from the due north direction was used as the third sampling point. To eliminate the effect of different sampling directions on the results, the soil moisture from the three sites was averaged for result analysis."

Table 3: Table 3 should be explained in more details. How do you classify soil texture fractions, i.e., the content of clay, silt and sand? What is the sampling depth? Are they mean values for different layers?

**Response:** According to the international standard for soil particle classification, we divided the soil particles into clay (<0.002 mm, %), silt (0.002~0.02 mm, %) and sand (0.02~2 mm, %). Sampling depth of soil particles was 10 m for each point, and Table 3 presents the average particle content value of all soil layers. These details will be edited in Table 3 as follows in the text.

**Table 3.** Basic soil properties of sampling sites.

| Sites | Plant species | Soil type | Clay | Silt | Sand | Soil organic metter (g $kg^{-1}$) | Bulk density (g $cm^{-3}$) | pH |
|---|---|---|---|---|---|---|---|---|
| Mizhi | Apple | Cultivated loessial soils | 15.5 | 24.3 | 60.2 | 2.94 | 1.28 | 7.64 |
| | Cropland | Cultivated loessial soils | 14.9 | 25.1 | 60.0 | 2.33 | 1.29 | 8.44 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Luochuan | Black locust | Cultivated loessial soils | 13.6 | 25.0 | 61.4 | 3.09 | 1.28 | 8.03 |
| | Grassland | Cultivated loessial soils | 13.8 | 25.4 | 60.8 | 2.35 | 1.29 | 8.36 |
| | Apple | Dark loessial soils | 21.5 | 37.1 | 41.4 | 4.62 | 1.31 | 7.54 |
| | Cropland | Dark loessial soils | 22.2 | 38.5 | 39.3 | 4.38 | 1.33 | 8.17 |
| Yan'an | Black locust | Cultivated loessial soils | 18.1 | 33.1 | 48.8 | 4.87 | 1.29 | 8.07 |
| | Grassland | Cultivated loessial soils | 19.6 | 31.5 | 48.9 | 4.43 | 1.30 | 8.53 |
| Changwu | Apple | Dark loessial soils | 24.6 | 38.7 | 36.7 | 4.76 | 1.31 | 7.35 |
| | Cropland | Dark loessial soils | 25.8 | 38.7 | 35.5 | 4.35 | 1.32 | 8.21 |
| | Black locust | Dark loessial soils | 22.9 | 38.2 | 38.9 | 5.01 | 1.29 | 7.96 |
| | Grassland | Dark loessial soils | 22.7 | 38.4 | 38.9 | 4.26 | 1.31 | 8.23 |

Note: Sampling depth of basic soil properties, including soil particles (which was divided into clay (<0.002 mm, %), silt (0.002~0.02 mm, %) and sand (0.02~2 mm, %) according to the international soil particle classification standard), soil organic metter, and pH was 10 m for different vegetation types, and the average particle content value of the different soil layers presented here. The soil bulk density presents the average value of 1 m soil profile.

Line 215: The index here can not represent degree limitation of soil desiccation, but just a relative soil water content.

**Response:** We agree. We will change the title to "Soil moisture deficit index" in the text (Line 228).

Line 231: The manufacture of the Canoco 5 should be added in the text.

**Response:** We agree. The manufacture of Canoco 5 is Microcomputer Power Ithaca, New York, USA, which will be added in the text (Line 250).

**Results**

Line 235: The analysis in 3.1 seems not closely connected with the following analyses in 3.2 and 3.3.

**Response:** The analysis in 3.1 indicated that the tree age at which the plantation had a biggest effect on DSM appears to be between 20 and 30 years. The analyses in sections 3.2 and 3.3 were based on this finding.

Line 240: Please change extreme to the biggest.

**Response:** We agree. It will be changed in the text (Line 260).

Line 260: Are these data used in the section 3.2.1 from published literature or your field sampling or the combination? Please clarify.

**Response:** Data in Figure 4(a) and (b) are extracted from literature, while data in Figure 4(c)-(f) belong to measured data. We will emphasize the source of the data before the analysis of the results as follows in the revised manuscript (Line 284).

"Combined with literature extraction (Fig. 4a and b) and measured (Fig. 4c-f) data to reveal the degree limitation of the DSM."

Line 265: This sentence is not clear. Please rewrite this sentence.

**Response:** Agreed. We will rewrite the sentence as follows in the text (Lines 290-291).

"Namely, the lowest values of DSM consumption were same as that of APO in different regions."

Line 268: What does extreme rainfall mean here? How much precipitation?

**Response:** The mean annual precipitation (MAP) of Changwu and Yan'an is 575 mm and 530 mm, respectively (Wang et al., 2022). In 2021, however, the annual precipitation is 910 mm and 704 mm, respectively (Table 1), which increased by 58.3% and 32.8% over MAP, respectively. Thus, we considered that the Changwu and Yan'an experienced an extremely wet year in 2021.

**Table 1.** Sample information used in this study.

| Sites | Species | NEP (pair) | NSP (pair) | MAP(mm) | 2021-P (mm) | Climate type zone |
|---|---|---|---|---|---|---|
| Luochuan | Apple | 24 | 10 | 608 | 957 | Semi-humid |
| Fufeng | Apple | 1 | - | 606 | - | Semi-humid |
| | Black locust | 4 | - | | - | |
| Yongshou | Black locust | 4 | - | 600 | - | Semi-humid |
| Changwu | Apple | 44 | 8 | 578 | 910 | Semi-humid |
| | Black locust | 6 | 10 | | | |
| Baishui | Apple | 2 | - | 577 | - | Semi-humid |
| Jingchuan | Apple | 1 | - | 571 | - | Semi-humid |
| Qingcheng | Apple | 6 | - | 561 | - | Semi-humid |
| Yan'an | Apple | 7 | - | 530 | - | Semi-humid |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Black locust | 15 | 10 | | 704 | |
| Daning | Apple | 2 | - | 528 | - | Semi-humid |
| Zichang | Apple | 1 | - | 480 | - | Semi-arid |
| | Black locust | 1 | - | | - | |
| Zizhou | Apple | 1 | - | 424 | - | Semi-arid |
| Mizhi | Apple | 9 | 10 | 421 | 441 | Semi-arid |
| | Black locust | 1 | 10 | | 458 | |
| Total | - | 129 | 58 | - | - | - |

Note: NEP and NSP indicate the number of data pairs from the literature and field sampling, respectively. A data pair refers to the moisture content of a soil profile from plantation and that of a soil profile from cropland/grassland. MAP is the mean annual precipitation; 250 mm<MAP<500 mm and 500 mm<MAP<800 mm are classified as the semi-arid and semi-humid climate zone, respectively (Wang et al., 2011). The blue text indicates the supplementary sampling in this study with reference to the existing data, and these are representative plots for the different climatic regions upon which we focused.

Reference:

Wang, S., Gao, X., Yang, M., Zhang L., Wang X., Wu, P., Zhao, X.: The efficiency of organic C sequestration in deep soils is enhanced by drier climates, Geoderma, 415, 115774, 10.1016/j.geoderma.2022.115774, 2022.

Figure 5: The yellow line in the Figure 5a is not clear. Please change it to another color.

**Response:** Thanks for your suggestion. It will be changed to a clear color in the revised manuscript.

Line 298: Soil texture can largely affect soil moisture. But, how can it lead to the degree and depth limitation of deep soil desiccation? The results here should be explained in a more sense way.

**Response:** Soil texture determines the adsorption force of the soil to the water molecules. The more clay content in soil, the more energy needed by plants to extract water from the soil. Therefore, for tree species with the same water uptake capacity, soil clay content and its' spatial distribution characteristics mainly determine the lower limit of available soil water, thus indirectly affecting the limitation of deep soil desiccation to plants.

**Discussion**

Line 340: Please add a citation here.

**Response:** We agree. Wu et al. (2015) will be cited here (Line 370).

Reference:

Wu, Y., Huang, M., Warrington, D.: Black Locust Transpiration Responses to Soil Water Availability as Affected by Meteorological Factors and Soil Texture, Pedosphere, 25(1), 57-71, 10.1016/S1002-0160(14)60076-X, 2015.

Line 347: Please delete "reference".

**Response:** We agree. It will be deleted in the text (Line 377).

Line 349: please change to soil water use.

**Response:** We agree. It will be changed to “soil water use” in the text (Line 379).

Line 354: Keep the decimal places consistent.

**Response:** We agree. It will be edited in the text (Line 384).

Line 355: Use the full name of SPAC.

**Response:** We agree. The full name soil-plant-atmosphere continuum will be added in the text (Line 385).

Line 378: Are the trees examined in your study site dieback?

**Response:** Yes, we took photos (as shown in the Figure S3 above) to record the black locust plantation of Mizhi where obvious dieback occurred with the help of digital camera at the same time of sampling.