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Reply on RC2

Mario Kirchhoff et al.

Author comment on "Spatial distribution of argan tree influence on soil properties in southern Morocco" by Mario Kirchhoff et al., SOIL Discuss., https://doi.org/10.5194/soil-2021-32-AC2, 2021

Dear reviewers,

thank you for the comprehensive and constructive reviews. We have made changes to the manuscript according to your comments. You can find answers to the comments further down point by point, our responses are highlighted in italic. Thank you very much for your time.

Referee 2

GENERAL COMMENTS

The topic of the work is current in terms of maintaining the fertility of the soil under arid conditions. It is an interesting study to evaluate spatial patterns of argan-tree influence. In general, this manuscript is acceptable, but the following issuers are still needed to consider.

SPECIFIC COMMENTS

Title

To my knowledge the use of the term soil quality is not appropriate in this study. There is a wide literature assessing soil quality, although some authors use a few parameters it is preferable to combine them and create a soil quality index (SQI).

Response: Thank you for this comment. We agree that the term soil quality is misleading and have changed the title accordingly to: „Spatial distribution of argan-tree influence on soil properties in South Morocco". We have also changed this issue in the text.

Abstract

Line 8-12: More generally, I suggest focusing the paragraph on the conducted study.

Response: Thank you, we added „…however, it is unknown if the trees influence the soil of the intertree areas."

Line 18-23: Some data obtained should be included

Response: We added SOC-data to show the decrease from tree trunk along tree drip line to intertree area. It is now: "We found that the tree influence on its surrounding intertree area is limited, with e.g., SOC- and TN-content decreasing significantly from tree trunk (SOC: 4.4 %, TN: 0.3 %) to tree drip line (SOC: 2.0 %, TN: 0.2 %). However, intertree areas near the tree drip line (SOC: 1.3 %, TN: 0.2 %) differed significantly from intertree areas between two trees (SOC: 1.0 %, TN: 0.1 %), yet only with a small effect."

Line 18: I suggest modifying the nomenclature: SOC to refer soil organic carbon and TN to refer total nitrogen. This should be modified in the whole text.

Response: Thank you for this comment. We have changed the nomenclature to SOC and TN throughout the text.

Introduction

I recommend reducing the length of the text while preserving the informative value in terms of brevity.

Response: Thank you for this recommendation. We deleted some sentences or merged them with others to reduce the length of the text.

I suggest moving Figure 1 to Material and Method section.

Response: Thank you. We moved it to the Material and methods section.

The authors should highlight the meaning or the purpose of this study in the introduction part. What kind of gap could you fill by doing this study?

Response: Thank you for this comment. In the last paragraph of the introduction we write about the research gap about spatial patterns of influence around argan trees. So far, only Zinke (1962) has written about influence patterns of single trees, but his research focused on pine forests in California and not on dryland forests. This last paragraph is based solely about the purpose/gap to be filled by this study:

"This hypothetical spatial pattern of influence of the tree on the soil has only been researched for pine trees (Zinke, 1962) but not at all for argan trees or dryland forests whereas the differences between tree or shrub vegetation and their corresponding intertree/intershrub areas have been investigated before, especially in 'fertile island'-research (e.g., Belsky et al., 1993; Boettcher and Kalisz, 1990; de Boever et al., 2015; Pérez, 2019; Qu et al., 2018). In South Morocco, where the geomorphologic processes are highly dynamic (Aït Hssaine, 2002; Kirchhoff et al., 2019b; Marzen et al., 2020; Peter et al., 2014), it is likely that litter and soil particles are dislocated to the intertree areas. The knowledge about this possible dislocation and improvement of soil parameter values in the intertree areas could enable a better regrowth in these areas (Boulmane et al., 2017; Defaa et al., 2015) or show the need for rehabilitation by limiting degradation factors like overgrazing.

The aim of this study is therefore to analyse the spatial distribution of the influences an individual argan tree has on soil properties of the intertree areas. For this purpose, we define

- "tree area" as the area covered by canopy (within the tree drip line),

- "intertree area" as all area not covered by canopy (i.e., between tree areas). "

Material and Methods

The Material and Methods section is poorly organized and very confusing.

Response: We have reorganised the Material and methods section. It is now: 2.1 Study area, 2.2 Experimental design (where we also moved Fig. 1 from the introduction), 2.3 Soil analyses, 2.4 Tension-disc infiltrometer experiments, 2.5 Statistical analyses.

I suggest major re-write of the study area section.

Response: Thank you for the suggestion. We re-wrote the section, thus reducing the length of the section. Each study area is now described in its own paragraph. It is now:

"The three study areas Ida-Outanane, Taroudant and Aït Baha are located in the western part of the Souss basin (Fig. 1, between 30° and 31° northern latitude and 9° and 7° western longitude). 30 test sites (one ha each) were chosen in these three environmentally differing study areas in order to cover varying altitudes, climate conditions and soil types (see Kirchhoff et al., 2019a).

Ida-Outanane is located on the southern foothills of the High Atlas close to Agadir and the Atlantic Ocean. Thus, its climate is more maritime with temperatures very rarely exceeding 30 °C and precipitation ranging from 230-260 mm (data for the suburbs of Agadir, 20 km away) (Díaz-Barradas et al., 2010; Saidi, 1995). Soils are mostly immature with Regosols, Leptosols and Fluvisols (Jones et al., 2013) covering Paleozoic, Mesozoic and Cenozoic rocks of the High Atlas (Hssaisoune et al., 2016). Traditional rainfed agriculture (mostly wheat cultivation) is practiced on three out of six test sites between the argan trees while the rest is under silvopastoral land use.

The study area of Taroudant also lies in the southern foothills of the High Atlas, but is situated further inland about 80 km from the coast. The climate is more continental with 220 mm annual precipitation and a mean annual temperature of 20 °C (Peter et al., 2014; Saidi, 1995). Eleven test sites are situated in the study area, seven on a loamy alluvial fan covering the Pliocene and Quaternary fluvial, fluvio-lacustrine and aeolian deposits of the Souss basin (Aït Hssaine and Bridgland, 2009; Chakir et al., 2014), the other four sites on the foothills of the High Atlas. The vegetation is mainly characterized by Argania spinosa as well as other shrubs and bushes such as Launaea arborescens, Ziziphus lotus, Acacia gummifera, Euphorbia spec. and Artemisia spec. (Ain-Lhout et al., 2016; Peter et al., 2014; Zunzunegui et al., 2017). However, a dynamic land use change has been taken place in the Souss basin for several decades, with traditional rainfed agriculture and argan trees being replaced by more profitable irrigated citrus plantations as well as greenhouses for banana and vegetable cultivation (d'Oleire-Oltmanns et al., 2012; Kirchhoff et al., 2019b; Peter et al., 2014).

The study area Aït Baha is located on the northern foothills of the Anti-Atlas Mountains. Precipitation ranges from 250-350 mm annually and the annual temperature averages 18.7 °C (Seif-Ennasr et al., 2016). The Anti-Atlas is mostly made up of Precambrian and Paleozoic rocks, which are covered by Fluvisols (Jones et al., 2013) as well as Regosols and Leptosols. Thirteen test sites are situated in this study area, with three on argan reforestation sites that often yield mixed results (Defaa et al., 2015). Silvopastoral land use dominates on most test sites with cereals being cultivated between the argan trees on ploughing terraces (on three test sites)."

Much more detail is required on how the experimental plots were design.

Response: We re-wrote the section, especially the part explaining the sampling points. It is now:

„To measure the potential influence of the tree on the intertree area shown in Fig. 2, we took 13 samples around each tree. One was taken next to the trunk, while we took three soil samples each in four directions around the tree, namely upslope, downslope and in both directions parallel to the contour lines. The three samples in each direction were taken with increasing distance from the tree, one near the tree drip line under the canopy, the next near the tree drip line just outside the crown's cover, and the third in the intertree area at the midpoint between the tree and its next neighbouring tree in that direction (Fig. 3). The two samples at the tree drip line were generally about one metre apart, depending on the crown's shape and the surface conditions.

The 385 disturbed surface soil samples were taken during a field campaign in February and March 2019 up to a depth of 5 cm. Since not all slopes were south-facing, transect directions were recorded in 8 directions of 22.5° angles each (e.g., N = 337.5 – 22.5°, NE = 22.5 – 67.5°). As the argan forest does not grow in a perfect grid pattern and the nearest tree in the sampling direction was not always in the exact direction needed, 90° differences between transect directions could not always be assured, but could vary some degrees to the left or right. For some trees less soil samples were taken due to the different tree densities and different tree architectures. For very dense, shrub-like trees it sometimes was not possible to sample the soil at the T2 sampling location because the soil was too well protected by the thorny, dense crown. Tree-tree distances on test sites with a high tree density could be very small, so that IT3 and IT4 sampling locations were the same on these test sites. Mean tree-tree distances on the test sites varied from 1.8 m to 17.5 m, with trees sometimes growing in tree groups and not being equally distributed on the test sites, so that some distances between trees could be much larger with a maximum of 50 m on one test site."

Figure 3 only provide precipitation at Aït Baha. Could you provide information of the other study areas?

Response: Because of a comment of Reviewer 1, we deleted Figure 3.

Line 104: Pleas clarify "ca."

Response: Because of the re-write of the section „Study area", we deleted this part.

Line 104: "Figure 3 shows that in recent years the annual precipitation of this study area has decreased to ca. 220 mm, possibly a sign of higher aridity due to climate change". This a very vague statement. In order to make this statement, a greater period of years is necessary, and Figure 3 only 15 years were included.

Response: Thank you for this comment. We deleted this part due to the re-write of the section.

Line 156: Please describe how 1-2 mm aggregates were obtained.

Response: The aggregates were sieved for the size 1-2 mm. We added this to the text.

Under which soil conditions were the infiltration measurements carried out? Were they homogeneous?

Response: We measured the unsaturated hydraulic conductivities in October/November

2019, when the soils were very dry. We took care to always measure the sampling locations T2 and IT3 at the same time for each test site, so we could compare the two sampling locations. The soil texture classes of T2 and IT3 were the same for 16 out of 19 test sites. We also added some information in the text: "At the time of the measurements in October/November 2019 soils were very dry in all three study areas (soil water content at the measurement points: 0.1 – 0.6 %). Soil texture classes were the same for T2 and IT3 sampling locations on 16 out of 19 test sites."

Results

Line 202-205: delete, it is described in table 2

Response: Thank you. We deleted it.

This section is well structured and well written. Illustrations used in the text are very useful and high quality.

Response: Thank you.

Discussion

Line 301-302: Reiterate the objective of the work is not necessary.

Response: Thank you. We have deleted the first sentence.

In some lines it is recommended to include current references (eg. 309 or 344).

Response: We have added some current references for these lines, namely De Boever et al. 2015, and Yang et al. 2020.

De Boever, M., Gabriels, D., Ouessar, M., and Cornelis, W.: Influence of scattered Acacia trees on soil nutrient levels in arid Tunisia, Journal of Arid Environments, 122, 161–168, doi:10.1016/j.jaridenv.2015.07.006, 2015.

Yang, C., Geng, Y., Fu, X. Z., Coulter, J. A., and Chai, Q.: The Effects of Wind Erosion Depending on Cropping System and Tillage Method in a Semi-Arid Region, Agronomy, 10, 732, doi:10.3390/agronomy10050732, 2020.

Line 322: "The medium to large effect for the unsaturated hydraulic conductivities could be explained by the higher porosity due to a higher content of organic" However porosity data is not available in the study. In this sense soil physical properties such as textural class or bulk density on microsite locations canopy and outside canopy for Argan trees are particularly relevant especially in an overgrazed environment. In addition, unsaturated hydraulic conductivity highly depends on soil's particle size distribution.

Response: Unfortunately, we did not measure soil porosity or bulk density in this study. We therefore changed the sentence: „De Boever et al. (2014) found that organic material correlated well with soil porosity and bulk density thus possibly explaining the medium to large effect for the unsaturated hydraulic conductivities between T2 and IT3 sampling locations." As mentioned above for the Material and methods, we added information if there were texture class differences between T2 and IT3 sampling locations.

Line 324-325: "In a previous study, we found higher erosion rates as well as lower infiltration rates in the intertree areas". Please provide data erosion rates as well as

infiltration rates.

Response: We have added the suspended sediment concentrations as well as infiltration rates from the previous study and replaced erosion rates with suspended sediment concentration rates. It is now: "In a previous study, we found higher average suspended sediment concentrations (4.42 g L^{-1} compared to 2.18 g L^{-1} under argan trees) as well as lower average infiltration rates in the intertree areas (229.56 mm h^{-1} compared to 452.57 mm h^{-1} under argan trees) (Kirchhoff et al., 2019a)."

Line 343: "large aggregates" Macroaggregates seems more appropriate.

Response: We have changed it to macroaggregates.

Line 352: "The type of tree (architecture, size, genetic variety) could be a possible explanation for the missing significance of the directions." However, there is no information in the text about type of tree selected (eg. Crown diameter or tree age) and it seems to be a relevant aspect in the conclusions. Has any pattern been followed to choose the analysed trees? If you have measured some parameters related to tree typology, please add them.

Response: We have added some information about the variation of trees to the subsection Experimental design: „Therefore, sampled trees were between 1 and 8 m high and varied from tall trees with round crowns to very dense shrub-like tree forms. Tree density varied from 3 to 292 trees ha$^{\square 1}$." However, more research is needed on how or if the different tree architecture or degradation states influence the soil. We plan on investigating this issue in a further study but so far have not done so.

Line 361: "Although the soil quality decreases from T1 to T2, the T2". A soil quality index has not been developed to support this statement.

Response: Thank you for this comment. We changed soil quality to „most of the measured soil parameter values".

Line 364: (Qu et al., 2018) reference missing.

Response: Thank you for pointing this out. We have added the reference.

Qu, L., Wang, Z., Huang, Y., Zhang, Y., Song, C., and Ma, K.: Effects of plant coverage on shrub fertile islands in the Upper Minjiang River Valley, Science China Life Sciences, 61, 340-347, doi: 10.1007/s11427-017-9144-9, 2018.