In this paper, electrical resistivity tomography and electrical current imaging are used to monitor water content distributions and the distribution of electrical current from the root system into the soil. The experiment is carried in a rhizobox, so that transpiration rates and total soil water contents could be monitored carefully. The water application is alternated between the two different sides of the box and is changed over time to generate a certain stress level in the second part of the experiment. To my opinion, the most interesting outcome of the study is that the electrical source when an electrical current is injected in the plant shoot, is apparently more homogeneously distributed (one could assume homogeneously distributed along the root length) when stress occurs. Another important result is that with ERT, the water content changes over time could be imaged quite accurately.

In the following our response to the reviewer’s comment is written in blue.

We express our gratitude to the reviewer for providing valuable and constructive feedback on our work and for highlighting the interesting outcomes. We have carefully considered and addressed all of the reviewer's comments, which we believe have significantly enhanced the quality of the manuscript. We were particularly impressed by the reviewer's suggestions in interpreting the results and we would be happy to cite his review directly in the manuscript.

The main changes we have made include:

(i) improvement of figures quality (consistent colours), proofreading the text for typos and rephrasing it when necessary.

(ii) Modifying the description and discussion of our experiment by replacing "PRD" with "root water limited availability," as indicated in the revised title. This change had only a minor impact on the actual results, as they were already aligned with.

(iii) Responding to the reviewer's comment by incorporating new references in the introduction that briefly cover various methods used to measure root physiology, anatomy, and biomass. By discussing the assumptions associated with these methods, we are able to establish up-to-date parallels between current pathways and water pathways.

(iv) Completely reshaping figures 8 and 9 and discussing the observed current density in this experiment, considering it as a result of both higher transpirational demand and/or drier soil conditions.

These revisions and improvements have enhanced the manuscript, and we sincerely appreciate the reviewer's insightful comments that have contributed to its overall quality.

A first main comment on the paper is that the authors describe their experiment as a partial root zone drying experiment. But, in such type of experiments, a part of the root zone is continuously kept wet by nearly continuous application of water to a part of the root zone using for instance drippers, whereas the other part is left to dry out. In their experiments, water is also applied to a part of the root zone and the application is alternated between the two sides. But the duration between the applications, is quite long so that both parts of the root zone dry out to the same level and water can flow from one part to the other. These conditions do not really generate a spatially variable root water uptake. The authors correctly recognize that their experimental setup did not exactly reproduce partial root zone drying experiments. To avoid confusion, I would propose not to call the experiments PRD experiments.

The reviewer's assessment is accurate: our intended "PRD" technique does not selectively stress half of the plant but rather imposes stress on the entire plant. This aligns perfectly with the results, which indicate that the plant attempts to extract water from both sides due to its lack of knowledge about the water source or its origin. During our discussion, we acknowledged that our experimental setup did not precisely replicate partial root zone drying experiments, as pointed out by the reviewer. Consequently, we addressed this main comment by adjusting the terminology; specifically, we replaced all instances of "PRD" with "limited water availability."

The title was rephrased (also considering the comment by Reviewer 1).
"*Imaging of the electrical activity in the root zone under limited water availability stress: A laboratory study for Vitis vinifera.*"

A second main comment is on the relation between soil water content changes and root water uptake and the interpretation of current source distribution images. Due to water redistribution in soil, local soil water content changes must not be interpreted as local root water uptake. In the text, the authors seem to allude to this although they do not use this approach when interpreting the electrical resistivity images.

We acknowledge the reviewer's comment and have revised our interpretation of root water uptake (RWU) by taking two actions:

- We added a paragraph into the introduction to develop this concept:
  "*The correlation between root water uptake and soil water content changes exists when averaged over a larger spatial scale than the scale at which soil moisture redistribution can compensate for local root activity. The determination of these spatial scales depends on the soil's hydraulic properties. The correlation between root water uptake and changes in soil water content can also be influenced by the time scales in addition to spatial scales. The ability to discriminate between them relies on factors such as the soil hydraulic properties, rates of local water extraction, and the temporal dynamics of water redistribution in the soil (Anonymous Reviewer, 2023)**"
- The results and discussion of the manuscript were carefully reviewed to ensure that local fluctuations in soil water content were not mistakenly attributed solely to local root water uptake.

*Anonymous Reviewer: Comment on bg-2023-58, https://doi.org/10.5194/bg-2023-58-RC2, n.d.

Concerning the current source distributions, there it would be helpful if the authors could make the analogy between water and electrical current flow in the soil root system. The distribution of both depends on the distribution of the water and electrical conductivities in the soil and the plant/root system. In unsaturated soil, both conductivities change with the water content and they also change very close to soil-root interface so that the conductances close to the soil-root interfaces may differ considerably from the bulk soil conductances, The latter changes depend strongly on the local flow densities near the root surfaces and hence on the transpirational demand. To my understanding, the results that are presented (how the current density distribution changes when water stress occurs, which is mainly the result of a higher transpirational demand and not of drier soil conditions in this experiment) suggest that these changes in conductances of both water and electrical conductances near soil-root interfaces may explain these observations.

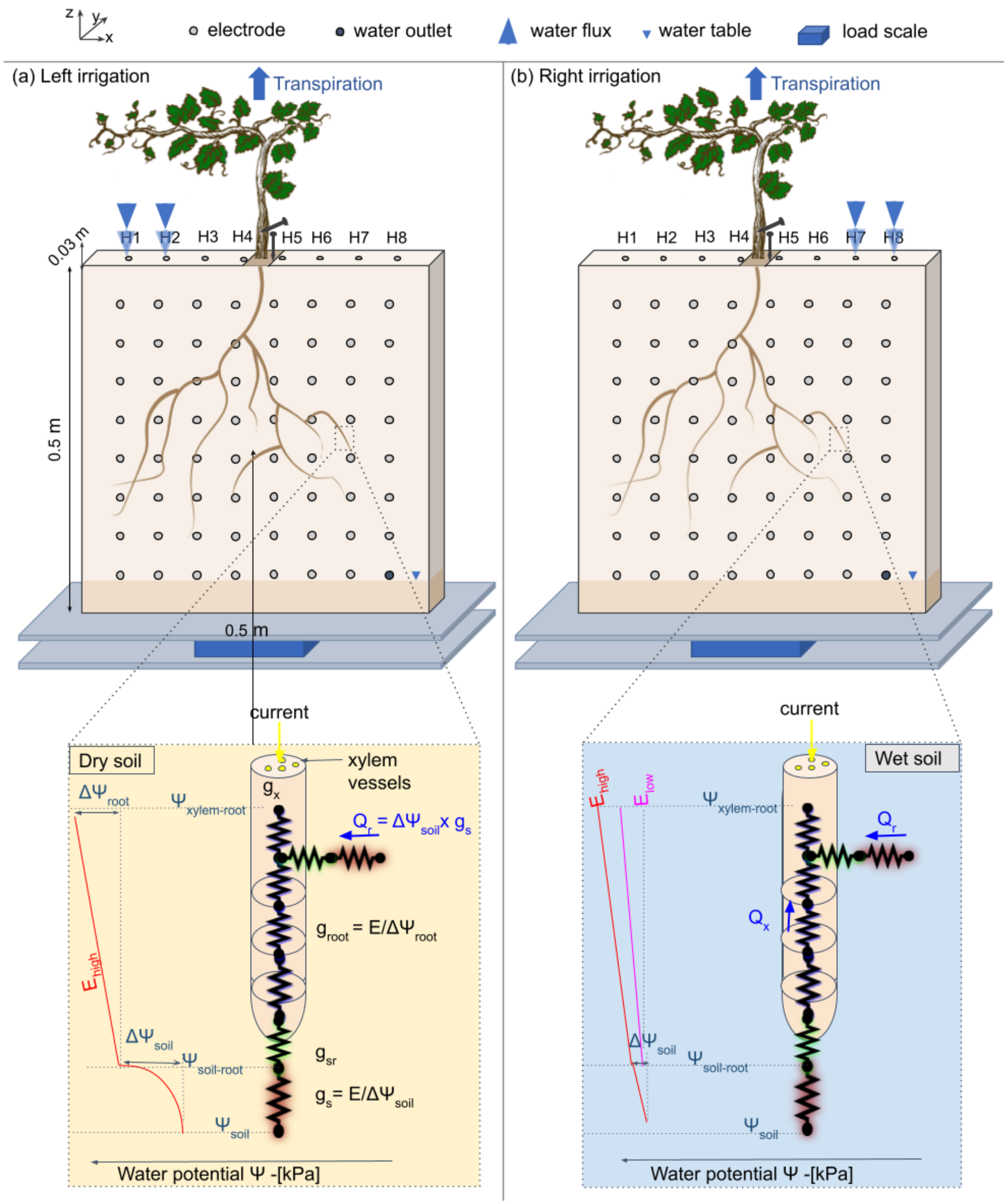
We agree with the reviewer.

Gradients in matric potential occur between the bulk soil and the soil–root interface once plants start to transpire. During soil drying, how quickly and how far $\psi_{soil\text{-}root}$ deviates from ψ_{soil} with increasing transpiration depends on soil textures and root hydraulic phenotypes.

To give a hint, we made a tentative conceptual figure to understand the analogy between water and current flow in the soil root system based on and possible use for our experiment specificity i.e. knowing that both soil water and transpiration rate could have affected the current pathway. The figure is inspired from the following papers:

- (Cai et al., 2022), figure 1
- (Doussan et al., 1999) figure 1
- (Manoli et al., 2014) figure 1
- (Couvreur et al., 2012)

We added a sentence in section 1.1 to explain the conceptual figure "*According to Fig.1, the gradient Δψsoil = (ψsoil- ψsoil-root) is higher in dry soil than in wet soil. The soil conductance gs is equal to the evapotranspiration E divided by Δψsoil, and thus gs increases when the soil dries and E remains constant. The same occurs for the root conductance gr . The root axial water flow rates Qx (L3T−1) and root radial water flow rates Qr (L3T−1) can be solved analytically by solving the system of equations of Ohm's and Kirchhoff's laws (Couvreur et al., 2012).*"



electrode
water outlet
water flux
water table
load scale
(a) Left irrigation
Transpiration
H1 H2 H3 H4 H5 H6 H7 H8
0.03 m
0.5 m
0.5 m
current
Dry soil
xylem vessels
ΔΨroot
Ψxylem-root
Qr = ΔΨsoil x gs
groot = E/ΔΨroot
Ehigh
ΔΨsoil
Ψsoil-root
gsr
gs= E/ΔΨsoil
Ψsoil
Water potential Ψ -[kPa]
(b) Right irrigation
Transpiration
H1 H2 H3 H4 H5 H6 H7 H8
current
Wet soil
Ehigh
Elow
Ψxylem-root
Qr
Qx
ΔΨsoil
Ψsoil-root
Ψsoil
Water potential Ψ -[kPa]

Figure 1: Conceptual figure showing the position of the plant in the rhizotron. The water input was done alternatively from left (a) to right (b) via small holes on the top of the rhizotron (H1 to H8). The roots are free to grow on both sides of the rhizotron. The circles on the screening face show the locations of the electrodes. Two additional electrodes (needles) are used for the ECI, one for the stem injection and the other for the control soil injection next to the stem. The rhizotron is weighted by a central point load scale (PC60-30KG-C3, Flintec) mounted between two support plates in plexiglass. The line below describes the state of the art of hydraulic conductivity at a single root and the distinction between dry (c) and wet (d) soil. The figure draws inspiration from the electrical circuit analogy of RWU (Root Water Uptake) proposed in previous works (Doussan et al., 1999, Manoli et al., 2014 and Couvreur et al., 2012). In a recent article, Cai et al. (2022) schematized the gradient of potential ψsoil, ψsoil-root and ψroot, along with the corresponding hydraulic conductances of the soil, the soil-root interface, and the root (represented as gs, gsr, and gr, respectively), in response to high or low transpiration demand (E). Note that the soil-root interface and the xylem cell interfaces are seats of current polarization due to the formation of the Electrical Double Layer (EDL) well described in Tsukanov and Schwartz (2021).

Along the same lines of reasoning, I do not think that under conditions when soil electrical conductances are high near the soil root interface and when there is good electrical contact between soil and roots, current source density distributions are related to water uptake distributions.

We agreed with the reviewer's opinion. Nevertheless, given the current state of the art, there is no demonstration of this given the fact that up to now the relationship between water and electrical conductances has not been firmly established. This is clearly something that we wanted to address in this article, particularly from the original Fig. 9.

A third main comment is that the interpretation presentation of the results is often not clear to me. For instance, figure 8 seems to suggest that resistivity increases with increasing water content. This is opposite to what is generally known and opposite to Archie's Law. At several points, I could not follow the reasoning of the authors and the text should be proofread carefully. I noted a few spelling errors but these are not exhaustive.

We acknowledged that Figure 8 contained evident errors caused by inaccurately interpolating weight data during the ERT acquisition time. In response, we made the decision to replace Figure 8 with a simplified comparison, demonstrating a direct 1:1 correlation between the variations in soil water content inferred from the scale and those derived from the ERT. Further information and detailed explanations can be found in our response to question Ln454.

Below are detailed comments that were written during a first read of the paper. They reflect my confusion that sometimes occurred when reading the paper.

Introduction: The introduction part on the electrical capacitance and electrical current imaging should be clearer by better stating which assumptions are made in these methods and which root traits and soil properties could (potentially) be derived from these methods. For instance, in capacitance imaging, a lumped property of the root system is derived. But it was not immediately clear to me how that is done and what the underlying assumptions are. Which assumptions about the axial and radial electrical conductances of the root system are made and how do these properties determine the total root system capacitance? It would be helpful if an analogy to root system properties that relate to water flow could be made, like root system conductance (root system capacitance for water flow is generally not considered).

We respectfully disagree with the reviewer's comment as the assumptions regarding the radial and axial electrical conductances were clearly stated, and their influence on the estimation of the total system capacitance was extensively documented with multiple references.

Another issue is that is not clear to which electrical properties of the root system is referred to. I think both capacitance and resistance should be considered. Finally, the abbreviations used are confusing: ECroot stands for capacitance of the root system, ECI for electrical current imaging. Note that EC is often used for electrical conductivity.

We added a new paragraph in the introduction (1.1) to recall the main application range and variations of stem-based methods:

"*There is a variety of methods used in the literature with applications ranging from biomass estimation, root morphology to root physiology (root activity). At a single frequency, we distinguish between ECM methods which rely on capacitance measurements and are commonly used to study root systems at the plant scale, and EIM, which measures both capacitance and resistance. Capacitance represents the polarization processes and measures the charges stored during the current flow. Both use the fact that the root can polarize at the soil-root interface and inside the root to infer direct root-related information such as dry and wet mass, surface area,...). A second group of methods Electrode Impedance Spectroscopy (EIS) uses a range of frequencies to capture the polarisation processes sensitive to the root physiology and anatomy. For a detailed description of the methods, the reader is invited to refer to (Ehosioke et al., 2020).*"

ECroot is now written fully as "root electrical capacitance" to avoid any confusion with ECI.

Ln 32 'The partial root zone drying (PRD) method is part of an ensemble of irrigation strategies that aim at improving water use efficiency. It consists of irrigating only one part of the root system of the same plant using a certain percentage of the potential evapotranspiration (ETp), usually inferior to the total water needed.' I would be great if you could include some explanation about the difference between partial root zone drying versus deficit irrigation and why a partial drying of the root zone would lead to a better result than drying of the entire root zone. In fact, as it turns out later, in the experiment that was conducted, the whole root zone dried out during a drying cycle.

We added a sentence in the introduction to mention the differences in the pros and cons of PRD VS DI.

"*Under conditions of high evaporative demand, both PRD (Partial Rootzone Drying) and DI (Deficit Irrigation) led to increased stomatal closure. This reduction in stomatal conductance in* *response to soil water deficit is attributed to the production of abscisic acid (ABA) in roots, triggered by the drying soil (as reviewed in Loveys et al., 2000; Davies et al., 2002). Notably, if there is adequate sap flow through the roots, the ABA signal is transmitted through the xylem to the leaf, as demonstrated by Dodd et al. (2008). According to Davies and Hartung (2004), it is proposed that plants subjected to partial root-zone drying (PRD) demonstrate improved performance compared to plants under deficit irrigation (DI) when an equal amount of water is applied. This is attributed to the ability of PRD to stimulate root growth and maintain consistent signalling of abscisic acid (ABA) to regulate shoot physiology. Davies and Hartung (2004) stated that the effects of PRD on plant growth, yielding and functioning are quantitatively different from those of RDI. One of the advantages of PRD when operated properly, is that plants sustained and even increased shoot and fruit turgor even though a reduced amount of water is applied to roots (Mingo et al., 2003). On the other hand, one of the disadvantages of RDI is that the entire root zone is allowed to dry out, the roots can become stressed and damaged and if not rewetted can die and signalling may diminish. Conversely Fernández et al. (2006) stated that not always a PRD treatment has been found advantageous as compared to a companion regulated deficit irrigation (RDI) treatment and demonstrated it in a study on olive trees in which sap flow measurements, which reflected water use throughout the irrigation period, showed no evidence of stomatal conductance being more reduced in PRD than in RDI trees. Collins et al. (2009), in an experiment on the grapevine (Vitis vinifera L.) show that the response to PRD applied at 100% ETc and deficit irrigation applied at 65% ETc was the same, increasing stomatal sensitivity to vapour pressure deficit and decreasing sap flow.*"

Ln 35 'Application of PRD triggers a physiological response in the plant via a hormone called Abscisic acid (ABA), which is produced in the roots and transmitted to the leaves to regulate the stomata closure and thus reducing water transpiration while keeping photosynthesis active and finally leading to increased water use efficiency.' What is different compared to entire root zone drying? Why is it important to dry out only a part of the root zone?

See the response to the previous question. We also added a sentence to stress the importance of soil study in understanding reduction in stomatal conductance:
"*According to (Cai et al., 2022), while stomatal conductance is a significant above ground hydraulic factor influencing water use in crops, it should not discount the role of belowground hydraulics, as changes in soil-plant hydraulic conductance have been found to drive stomatal closure (Abdalla, Carminati, et al., 2021). This highlights the crucial importance of studying electrical activity in the soil.*"

Ln 48: 'soil moisture patterns determined by PRD are visible from the ERT perspective and can be attributed to the root system distribution.' What do you mean by this sentence? What is meant specially by 'attributed to the root system distribution'? Do you mean that the pattern of drying in the part of the root zone that does not receive water can be related to the distribution of the roots in this zone?

Thanks for spotting this. Sentence rephrased:

"*The observed drying pattern resulting from an elevated evapotranspiration rate (ER) in the non-irrigated section of the root zone matches the root distribution in that area, while the observed wetting pattern arising from a decreased ER in the irrigated section of the root zone can be attributed to the irrigation itself.*"

Ln 50 'Roots induce changes in the soil structure in terms of porosity and hydraulic conductivity which ultimately modify the water pathways and fluxes and thus the ER itself.' This is certainly correct but isn't the question to what extent this is a secondary effect compared to the primary effect that is caused by the uptake of water by the roots?

The reviewer's observation is valid: alterations in soil structure may have a lesser impact on Electrical Resistivity (ER) compared to root water uptake (RWU). However, it should be acknowledged that this relationship may not hold true for species with extensive root systems, such as woody species. This aspect also intersects with the discussion on water redistribution and channelling. During rainfall or irrigation events, the ER in the root zone can undergo significant changes, influenced by the root anatomy which varies among different root systems. Further investigation is necessary to gain a deeper understanding of the intricate interplay among soil structure, RWU, and ER in this context.

One sentence was added:
"*Soil structure changes may have a relatively smaller effect on ER than root water uptake RWU, although this may differ for species with extensive root systems like woody species; this is further true during rainfall or irrigation considering water redistribution and channelling influenced by varying root anatomies and causing dynamic variations in ER.*"

Ln 90: 'appoplastic' should be 'apoplastic'

Corrected thanks

Ln 97 'complex balance between reducing radial flow (as a consequence of ABA signaling sent by the roots) to conserve water in the soil but keeping the axial flow active.' I am not following the reasoning here. How can axial flow be kept when radial flow is blocked? The reason for reducing the radial flow in dry soil is not to conserve water but to avoid too strong water potential drops between the soil and the plant. By reducing radial conductivity in dry regions, plants shift the uptake towards wetter regions where the soil conductivity is higher so that plants can take up water at the same rate but keeping higher plant water potentials.

The reviewer is right this can be confusing and we rephrased the sentence and added a reference.
We meant that there is a trade-off between radial and axial flow. Obviously, at a single root scale, the axial flow cannot be kept when the radial flow is blocked but there could be a balance. We replaced balance by tradeoff. Aroca R (2012)* describes in a generic manner the plant responses to drought stress. Furthermore, we think that the tradeoff is what the suberization

induces i.e. it keeps a good longitudinal conductance but limits the radial one.
*Aroca, R., Porcel, R., and Ruiz-Lozano, J. M.: Regulation of root water uptake under abiotic stress conditions, Journal of Experimental Botany, 63, 43–57, https://doi.org/10.1093/jxb/err266, 2012.

Ln 114: 'Without being able yet to give hints about the electrical current pathway, recent advancements in the development of explicit RWU models, based on plant hydraulics, provide insights into how robust capacitance models hold and under which conditions. We learnt, for instance, that at the root level, RWU models account for the anisotropy by separating the root hydraulic conductance into two terms (longitudinal and radial).' I think the authors should give references here to explicit RWU models and also refer to work that used these models to simulate electrical currents (and polarization) in root systems (see for instance work by Mathieu Javaux and colleagues and Nimrod Schwartz and colleagues).

We cited (Javaux et al., 2008; Couvreur et al., 2012). As for the work from Weigand, 2017; Weigand and Kemna, 2019; Tsukanov and Schwartz, 2020, 2021 they are more centred around polarisation than RWU so It was mentioned directly in the introduction.

Ln 119: 'Up to now the relationship between root water content and root hydraulic conductivity with electrical resistivity has not been firmly established. Many other parameters can affect the water flow as well as the current pathway of stem-based methods.' This is quite vague, especially in view of work done by others previously. Which 'other parameters' are you referring to?

Many "other parameters" are now replaced by "root function, age, water retention capacity and transpiration rate in particular (Ehosioke et al., 2020)"

Ln 132: I suppose you are referring here with EC to electrical capacitance. This may be confusing for many readers since EC is typically associated with electrical conductivity. I am also wondering why you use capacitance and not impedance, which combines both capacitance and resistance. I suppose the signal that is measured is also related to the electrical resistivity or conductance of the root tissue and of the soil and not only by the capacitance.

Initially, we used EC to relate to electrical capacitance as the studies cited are using this terminology. Nevertheless, we agree with the reviewer's suggestion that impedance would be more appropriate here. All occurrences of EC were substituted by impedance.

Ln 151: 'we aim at showing that the current path through the root system is linked to the active root zones.' Doesn't this imply that it is assumed that soil and root hydraulic conductances are positively correlated to electrical conductances?

The reviewer's observation is accurate, from a current pathway or hydraulic conductance perspective, the assumption of a positive correlation between soil and root hydraulic conductances and electrical conductances yields similar outcomes. However, it is important to note that in the introduction (ln114 to 121), we explicitly stated that the relationship between root water content, root hydraulic conductivity, and electrical resistivity lacks definitive evidence. Consequently, establishing this relationship constitutes one of the key objectives of our study.

To enhance clarity, we have reformulated our aims to make them more explicit, particularly for readers who prefer to approach the topic from a hydraulic perspective.

BEFORE:
"*The aim of this study is twofold:*
(i) we aim at showing that the current path through the root system is linked to the active root zones
(ii) …
"

AFTER:
"*The aim of this study is twofold:*
(i) we aim at showing the correlation between the current path through the root system and the active root zones. This assumption is based on the notion that soil and root hydraulic conductances are positively associated with electrical conductances.
(ii) …
"

Ln 158 'changes in soil water content measured by ERT are a relevant spatial proxy of root activity' It has been discussed in several papers that changes in soil water content do not map to distributions of root water uptake or root activity. Local root water uptake can be compensated by water redistribution in the soil and decouple local water content changes from root water uptake. Maybe it is better to write that root water uptake and soil water content changes that are averaged over a spatial scale that is larger than the scale over which water redistribution in the soil can compensate soil moisture changes due to local root activity, can be correlated. These spatial scales depend on the soil hydraulic properties and the local extraction rates.

(Repeated response from main comment #2)

We acknowledge the reviewer's comment and have revised our interpretation of root water uptake (RWU) by taking two actions:

- We added a paragraph into the introduction to develop this concept:
  "*The correlation between root water uptake and soil water content changes exists when averaged over a larger spatial scale than the scale at which soil moisture redistribution*

can compensate for local root activity. The determination of these spatial scales depends on the soil's hydraulic properties. The correlation between root water uptake and changes in soil water content can also be influenced by the time scales in addition to spatial scales. The ability to discriminate between them relies on factors such as the soil hydraulic properties, rates of local water extraction, and the temporal dynamics of water redistribution in the soil (Anonymous Reviewer, 2023)"

- The results and discussion of the manuscript were carefully reviewed to ensure that local fluctuations in soil water content were not mistakenly attributed solely to local root water uptake.

Ln 162: 'during the application of PRD, only one part of the root system would be active and the current injected in the stem would preferably spread to the side where the root system is irrigated.' This assumption seems to be contradictory in itself. Partial root zone drying only occurs when the part of the root system in the region that does not receive extra water can remain active for a while. So I think it is better to write, ' When during the application of PRD, the part of the root system in the dry zone is deactivated, current injected in the stem would preferably spread to the side where the root system is irrigated.'

Ok, sentence rephrased: "*During the implementation of root-zone limited water availability when a portion of the root system in the dry zone becomes deactivated, injected current in the stem tends to preferentially propagate towards the side where the root system is irrigated.*"

This assumption hinges on the assumption that a deactivation of the root system part in the dried out zone corresponds with an increase in root and/or soil electrical resistivities. That electrical resistivities of soil increase with soil drying is trivial. But, the question is whether electrical resistivities of the coupled soil-root system increase to the same extent with soil drying as the hydraulic resistances and decreasing soil-plant hydraulic potential differences. I suppose this hypothesis will hold true in coarser soils but for clay soils, this can be questioned.

The reviewer is right pointing at the lack of definitive evidence for the hypothesis. Yet one may consider the analog of classical contact resistance between e.g. metal electrodes and soil, that also increases as soil resistivity increases (e.g. when the soil gets drier).

Figure 1: give indications of the height, width and depth of the rhizobox in figure 1.

The experiment was conducted using a rhizotron 50 cm wide, 50 cm high, and 3 cm thick. We added it to the figure directly as suggested.

Ln 180: 'An outlet point was placed on the bottom right side (z=5cm) and the rhizotron was always saturated below this point. In the course of the experiment (after the growing period) no water discharge was observed through the outlet point.' How was the bottom of the rhizobox kept saturated? Was the outlet connected to a Mariotte system? Was regularly water added? If no water was added at the bottom, then I wonder why the bottom remained saturated.

No, a Mariotte system was not employed in our study. The visible observation from the screening face of the rhizotron, where the soil below the outlet point appeared saturated, can be attributed solely to the outlet point being positioned above ground level. The only possible ways for the soil to desaturate would be through soil suction or root water uptake (RWU), but visually, this was not observed.

Ln 295: '(2) time-lapse inversion (difference inversion) where the difference in resistivity is inverted between a given survey and a background survey (in this case, the background survey is the previous one).' Here it is important to give the time difference between the two measurements. In order to be interpretable, the time difference should always be the same. Were daily measurements taken always at the same time of the day?

Daily measurements were not consistently conducted at a fixed time, varying between 12:00 and 18:00 when the light is on. However, the time interval between irrigation and subsequent measurements remained consistent for each cycle with H+1 and D+6. To provide clarity, we included the irrigation time in Table 1 and the figure header.

Ln 417: 'Time steps correspond to measurements before (a), after one hour (b) and after 6 days (c).' I do not understand well how the differences are calculated and what the time step of the differences are. Was every day measured at the same time or at different times? Was the difference calculated between the measurement at a certain day and the day before it or was it calculated from the difference between the measurement and the measurement at the start of the irrigation cycle.

Based on the feedback from reviewer 1, we acknowledged that the figure legend was causing confusion. In response to this, we made the necessary changes to the table header to provide clearer indications of the time steps. Additionally, we extended these modifications to the figures included in the Supplementary Material to ensure consistency and facilitate better comprehension.

(a) Background (-4h) = 2022-06-29 9:30	(b) Just After Irrig. (+0h15) = 2022-06-29 14:15	(c) 6 days after Irrig = 2022-07-05 16:35

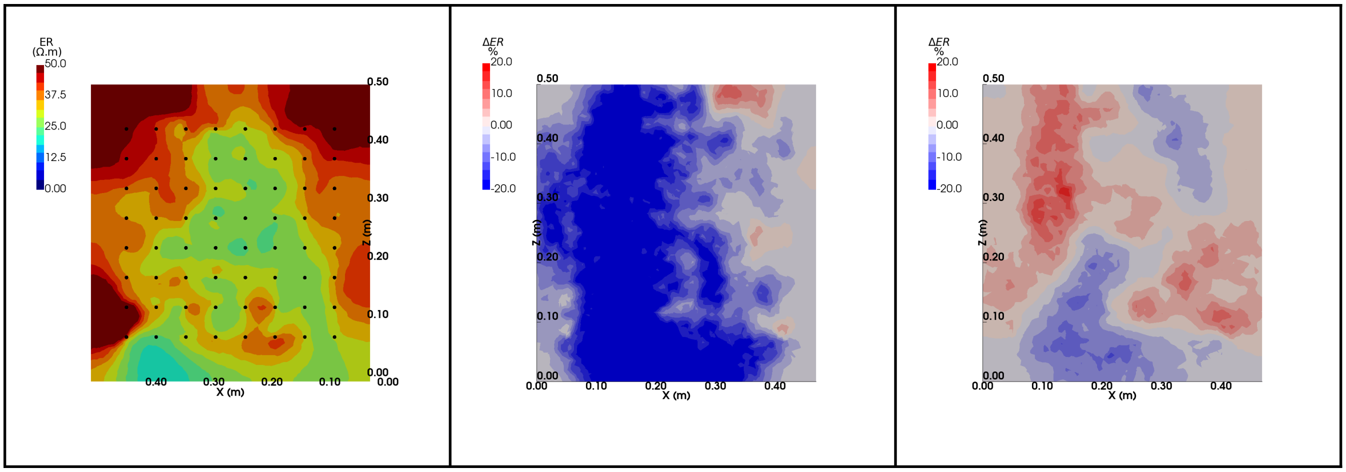
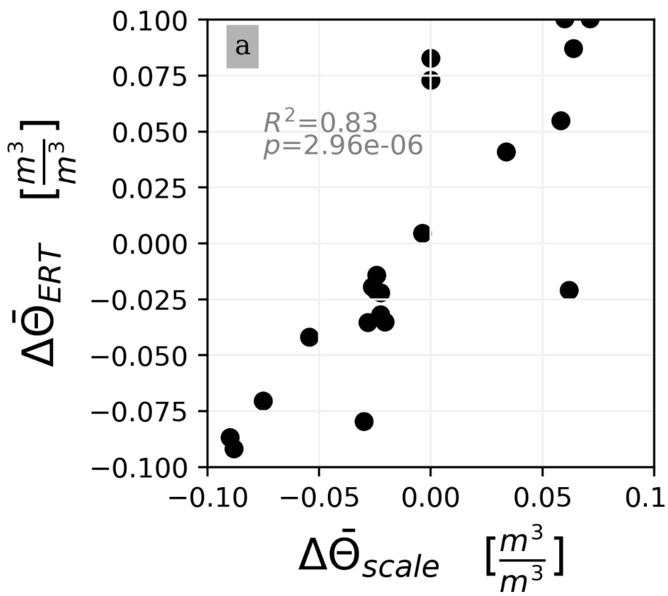


Figure 5: Spatial distribution of the resistivity (in Ωm) and changes (in %) in ER obtained by a time-lapse inversion for cycle 8 following partial left irrigation of the rhizotron (2022-06-29 13:45-14:00, 386 ml). Time steps correspond to measurements before (a), -4h min (b) just after irrigation (+0h15) (c) and 6 days after irrigation started.

Ln 454: 'Figure 8 shows the relationship between the variation between two consecutive measurements of the weights with the variations of average electrical resistivity (Fig.8a, R2=0.76, p-value=6.5 x 10-5) and those of resistivity-derived average water content (from Archie's law - Fig.8b, R2=0.815, p-value=6.8 x 10-6). An increase in weight over time is positively correlated with an increase in resistivity and water content meaning that the changes in resistivity are mainly associated with transpiration (rather than changes in soil structure or other parameters).' I do not understand these results.

You are plotting changes in weight over time versus resistivities or versus water contents. Shouldn't changes in weight be plotted versus changes in water content or changes in resistivity? Although I am not sure whether the latter makes sense since water content and resistivity are non-linearly related in Archie's Equation. But, what amazes me the most is that resistivity increases when the weight and hence the water content increases. This cannot be correct. Finally, from the changes in weight, a change in water content can be calculated. These changes in water content calculated from weight changes should be one-to-one related to the changes in water content calculated from the ERT measurements. I propose comparing those.

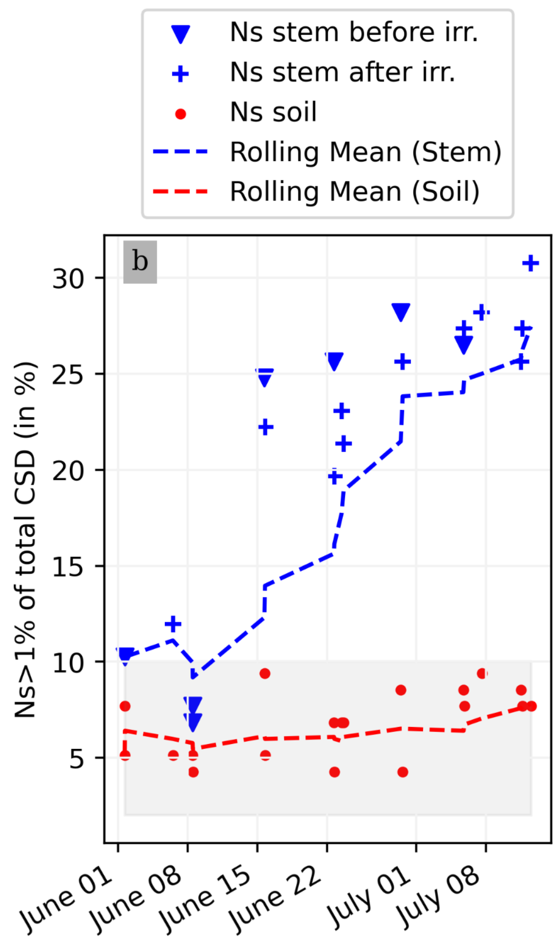
In a new figure, we plotted the change in water content inferred from the changes in weight versus the change in water content inferred from the ERT after Archie's transformation (see figure below). As expected this is a 1:1 relationship with consistent negative variations of SWC for both ERT and scale during irrigation time and positive variations during RWU/transpiration times.



In the revised manuscript, new results are described:
"*By examining the fluctuations in weight, one can calculate the corresponding changes in spatially averaged water content. Figure 8a illustrates a linear trend (R2=0.83 and p=2.96e-6) between the inferred water content variations from the scale and those obtained from ERT (after Archie transformation). The most significant negative changes in averaged water content are attributable to the triggered irrigation, leading to a ΔΘ (change in water content) of -0.1. Conversely, positive changes primarily result from transpiration, with a maximum value located at +0.1.*"

Ln 484: 'For cycles where stressed was not applied (i.e. < cycle 3), for the stem injection, Ns1 is distributed between 5 and 25%.' What is remarkable is that the distribution of sources is not related to the soil water content. At low water contents, when one would expect more stress, the distribution can be like the distribution for the soil injection or like the distribution when water stress is supposed. But also at high water contents, the distribution can be like the distribution when water stress is supposed. Can the grey triangles that are falling in the range of the black triangles be explained? Could they correspond with higher transpiration rates. It seems to me that the stress is related to the transpiration rate or transpiration demand which increases over time due to an increase in leaf area. At high transpiration demands or rates, stress may occur at higher soil water contents because then the soil becomes limiting for the root water uptake.

We replotted the figure by considering the time variation of Ns (Number of sources which carry at least 1% of the total current) (see Fig. 8b below) and demonstrated indeed that the distribution was not linked to the soil water level as there are no significant differences between before and after irrigation, but that Ns increase with the transpiration demand (via an increase of the leaf area index LAI).



In the revised manuscript, new results are described:
"*Figure 8b shows the relationship between the variation of the percentage of the current sources carrying at least 1% of the total density (Ns1) used as an estimator for current density dispersion with respect to the datetime of the experiment. For the soil injection (red dots), Ns1 is relatively constant between 5 to 10% of the total number of possible injection nodes (grey area). For the stem injections, Ns1 increases over the course of the experiment. From June 1st to July 8th, the Ns1 triple. The is no distinction between Ns1 measured before (triangle point) and after (crossed points) irrigation*".

and discussed:
"Based Fig. 2 and 8b, the association between water stress and leaf development, along with transpiration demand, is expected to be more prominent (and increasing during the course of

the experiment rather than the specific time points before and after irrigation). Indeed the fluctuations in water content during various cycles, with or without stress, exhibited remarkable similarity. Both stressed and non-stressed cycles experienced a drop in water content to similar low levels. Consequently, water content does not appear to account for the variability in water stress. Instead, it is the increased transpiration demand over time that seems to play a more significant role in driving the observed changes. At high transpiration demand, stress may occur at higher soil water contents because the soil becomes limiting for the root water uptake. The changes in water potential and water content in the vicinity of the soil-root interface can potentially impact the electrical conductivity of the immediate soil surrounding the roots. Consequently, as the experiment progressed, lower electrical conductances in the soil around the roots, potentially led to a restriction in the flow of current between the root system and the soil. This, in turn, may have resulted in a more uniform distribution of the electrical current source along the entire length of the root system."

Ln 501: Garre et al. 2011 is not in the reference list.

Well spotted, thanks we added it to the reference list.

Garré, S., Javaux, M., Vanderborght, J., Pagès, L., and Vereecken, H.: Three-dimensional electrical resistivity tomography to monitor root zone water dynamics, Vadose Zone Journal, 10, 412–424, https://doi.org/10.2136/vzj2010.0079, 2011.

Ln 505: 'Our observation is in line with the literature i.e. in general, low soil water content (SWC) can lead to drought stress in plants, which can result in decreased leaf stomatal conductance and less transpiration, and vice versa.' Actually, I think that your observations in fact show the opposite. The water content changes during the different cycles with or without stress were very similar and water contents dropped to the same low levels in cycles where no stress was observed as in cycles where stress was observed. Therefore, water content does not seem to be explaining variable for water stress. It rather seems to be the transpiration demand which increased over time.

We share the reviewer's perspective on the matter.

While it is true that stress levels escalated due to the increasing transpiration demand over time, it is worth noting that there were discernible differences in water stress at the conclusion of the irrigation cycle and one day after irrigation (on June 16, 2022) based on leaf stomatal conductance measurements, albeit with smaller variations.

In light of this, we incorporated a sentence to highlight that, overall, water stress appeared to be more closely linked to leaf development and transpiration demand rather than the specific before/post irrigation time points.

"*Based on Fig. 2, the association between water stress and leaf development, along with transpiration demand, is expected to be more prominent (and increasing during the course of the experiment) than the specific time points before and after irrigation*."

Ln 518: 'This is a hint that the hydraulically stressed plant tends to have a wider and deeper active root system, even not necessarily active only on the side where the PRD is temporarily applied. Possibly the reaction of the plant to the changing side is too slow to show up in our measurements, but the reaction to general stress is apparent.' I am sorry but you lost me here.

In this section, we focus on the initial stages of the experiment when stress was minimal, and the hydraulic conductance of the soil-root interface was likely high. The discussion concerning the current density distribution in relation to stress is presented later in section 4.2.

The sentence was rephrased:
"*Our observations potentially suggest that under conditions where soil electrical conductances are high near the soil-root interface and even if there is good electrical contact between soil and roots, the distribution of current source density might not be directly related to water uptake distributions. Further research is needed to confirm this potential relationship.*"

Ln 532: 'tend to show that mixed soil-root pedophysical relationships are preferable (e.g. Rao et al., 2018).' I think that rather than considering mixed soil-root pedophysical relations, it would be important to consider small scale variations around single root segments in water content and /or soil hydraulic properties.

The reviewer is right. Both concepts are related as mixed soil-root pedophysical relationships try to introduce knowledge about the soil-root relationship. We added a sentence to explicitly consider the reviewer's comment:
"*Moreover, considering small-scale variations around individual root segments in terms of water content and soil hydraulic properties becomes crucial for a comprehensive understanding of the system.*"

Ln 552: 'Additionally, capillary rise may have taken place due to the presence of a saturated zone at the bottom of the rhizotron' Yes, but then the water content at the bottom of the rhizobox should decline over time since no water was added at the bottom of the box?

See previous answer Ln 180. This statement has nevertheless been moderated by rephrasing:
"*Additionally, even not visible from the screening face capillary rise may have taken place due to the presence of a saturated zone at the bottom of the rhizotron*"

Ln 559: 'Given the stress applied, the ER changes highlighted that root played a major role in the wine plant survival and evidenced strategies of adaptation. Indeed, the plant was able to change its water uptake zones depending on the water availability, from all places, not only from the alternate irrigated areas.' I don't think this conclusion can be drawn from this experiment. Plant adaptation means an active adaptation of the plant to redistribute the water uptake.

- First, I am not sure whether uptake distributions were directly observed.
- Second, also without any adaption, the uptake distribution changes when the soil water content distribution changes, but also when the water uptake rate changes. The impact of water potential distribution on uptake distribution is trivial. The water uptake rate or transpiration rate may impact the uptake distribution since the soil water potentials near the soil-root interface will drop which leads to a drop in soil conductivity. This dependency on water potentials and flow rates make that the conductivity distributions in the soil-plant continuum, and hence the uptake distributions change with flow rate. I suppose that the change in water potential and water content close to the soil-root interface also had an effect on the electrical conductivity of the soil just around the roots. This means that later during the experiment, the electrical conductances in soil around roots were lower and might have become limiting the current between the root system and the soil. This would have generated a more homogeneous distribution of the electrical current source along the total length of the root system.

Regarding the first reviewer's concern, we only added and/or water redistribution to make sure that RWU is not the only strategy of adaptation for the plant to stress.

Sentence rephrased: "*Given the stress applied, the ER changes highlighted that root played a major role in the wine plant survival and evidenced strategies of adaptation. Indeed, the plant was able to adjust with water uptake* ***and redistribution*** *zones depending on the water availability, from all places, not only from the alternate irrigated areas*."

We already responded to the reviewer's "second" issue in the previous question (Ln 484) regarding the effect of the changing electrical conductances in the soil around roots and its consequences in terms of current distribution. We express our gratitude to the reviewer for providing us with their scientific perspective, which helped us explain the changes in current distribution over time. We have incorporated their valuable insights into our revised discussion.

Ln 612: 'We only evidenced that the Current Source leakage depth varied during the course of the experiment but without any significant relationship to the Soil Water Content changes or evaporative demand.' The current source leakage depth did not vary with transpirational demand or water content. But, didn't the spatial distribution of the leakage vary with transpiration demand and didn't you show that this was related to the occurrence of stress?

The reviewer is correct and this is even more apparent with the new figure 8b. Please refer to previous questions for more details on how this was described and discussed in the revised version of the manuscript.