

Volatile organic compound-mediated conversation in soil

Corresponding Author: Professor Waseem Raza

This file contains all editorial decision letters in order by version, followed by all author rebuttals in order by version.

Attachments originally included by the reviewers as part of their assessment can be found at the end of this file.

Version 0:

Decision Letter:

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Dear Professor Raza,

Your manuscript titled "The Scented Web: Long-distance VOC-Mediated Conversation in Soil" has now been seen by 2 reviewers, and we include their comments at the end of this message. They find your work of interest, but some important points are raised. We are interested in the possibility of publishing your study in Communications Earth & Environment, but would like to consider your responses to these concerns and assess a revised manuscript before we make a final decision on publication.

We therefore invite you to revise and resubmit your manuscript, along with a point-by-point response that takes into account the points raised. Please highlight all changes in the manuscript text file.

Please submit your point-by-point responses as a separate file, distinct from your cover letter where you can add responses to the Editors' comments that you do not want to be made available to the reviewers. Word files are preferred. We recommend that any figures, tables or graphs that are included in the response to reviewers are also included in the main article or Supplementary Information.

We are committed to providing a fair and constructive peer-review process. Please don't hesitate to contact us if you wish to discuss the revision in more detail.

Please use the following link to submit your revised manuscript, point-by-point response to the referees' comments (which should be in a separate document to any cover letter), a tracked-changes version of the manuscript (as a PDF file) and the completed checklist:

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We hope to receive your revised paper within six weeks; please let us know if you aren't able to submit it within this time so that we can discuss how best to proceed. If we don't hear from you, and the revision process takes significantly longer, we may close your file. In this event, we will still be happy to reconsider your paper at a later date, as long as nothing similar has been accepted for publication at Communications Earth & Environment or published elsewhere in the meantime.

Please do not hesitate to contact us if you have any questions or would like to discuss these revisions further. We look forward to seeing the revised manuscript and thank you for the opportunity to review your work.

Best regards,

Marisa McDonald, PhD

Associate Editor, Communications Earth & Environment
Consulting Editor, Communications Sustainability

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REVIEWER COMMENTS:

Reviewer #1 (Remarks to the Author):

Review report

The manuscript argues that VOCs are a “language” structuring belowground interactions across microbes, plants, protists, nematodes, and predators, and it identifies major knowledge gaps (mixtures, perception, multitrophic complexity, environmental modulation, pollutants/microplastics). This is a strong and attractive premise for a perspective. The writing is generally readable and the sectioning is logical. However, the current version sometimes over-claims “long-distance”

relevance without sufficiently separating what is well demonstrated in soil/field from what is inferred from microcosms/olfactometers/headspace assays. Several key statements would benefit from (i) more precise language about spatial scale and soil conditions, (ii) explicit limitations of existing approaches, and (iii) inclusion of missing cornerstone studies (including entomopathogenic nematode attraction to synthetic root volatiles).

1. A recurring weakness is that many examples come from simplified systems, but the manuscript sometimes reads as if mechanisms are established under realistic soil conditions. More clearly label evidence as *in vitro*/headspace, soil microcosm, mesocosm, or field. Add a short “Reality check” paragraph in each major section addressing: how soil structure, moisture, organic matter, and microbial consumption constrain VOC plumes, how concentration ranges used in assays compare with expected pore-air concentrations.
2. The introduction cites “up to centimeters” and later mentions 50 cm detection by nematodes. These are eye-catching, but risk being perceived as overstated unless contextualized with caveats (soil type, moisture, airflow, experimental setup). Define “long-distance” explicitly (mm vs cm vs tens of cm) and distinguish: diffusion through pore space vs. movement via preferential flow/macropores, detection distance vs. effective ecological influence distance.
3. The predator–prey/nematode sections rely heavily on classic citrus/weevil work and related cues. Two relevant studies are indeed missing and should be cited where you discuss EPN navigation toward synthetic volatiles:

Jagodič, Ipavec, Trdan, Laznik (2017) *BioControl* – synthetic volatiles from insect-damaged *Brassica nigra* roots and EPN attraction.

Laznik & Trdan (2016) *J. Pest Sci.* – synthetic volatiles emitted by insect-damaged carrot roots and EPN attraction behaviors.

These papers strengthen the manuscript’s argument that root-derived (and damage-induced) volatiles can function as navigation cues, and they broaden plant system coverage beyond citrus.

4. The manuscript correctly notes that VOC perception mechanisms are poorly resolved, but the discussion is still quite general. In a perspective, you can be speculative—but you should give readers a clearer map of plausible mechanistic routes in plants vs microbes vs nematodes/protists. Split perception subsection by organism group (plants / bacteria / fungi / nematodes-protists). Add a brief set of “testable predictions” (e.g., membrane perturbation signatures, receptor-like proteins, transcriptomic motifs, mutant phenotypes).
5. Minor comments: Proofread for spacing/typos (e.g., “microbesis”, missing spaces in “*Pseudomonas* species”, inconsistent hyphenation); Several references are repeated (e.g., similar entries appear multiple times); check duplication (e.g., refs 38/44; 45/58 look duplicated in your list). Some citations appear as “Preprint at ...” even when a final journal version may exist—please verify and cite published versions where available. Ensure consistency of “VOCs” vs “BVOCs” terminology in the soil section. Reduce absolute phrasing (“no information is available”)—often it is safer to say “limited information”.

Reviewer #2 (Remarks to the Author):

General comments

In their perspective article, “The Scented Web: Long-distance VOC-Mediated Conversation in Soil”, Ali et al. argue that volatile organic compounds (VOCs) are key signaling molecules in belowground interactions among plants, microbes, and other soil organisms. With this, the authors address a relevant and timely topic that is surely of interest to the readers of *Communications Earth & Environment*. My own scientific expertise lies more in plant physiology and interactions than in soil microbiology and fauna, which is reflected in the focus of my comments.

While I believe this manuscript has the potential to make a valuable contribution to the discussion of the ecological relevance of soil VOCs, several aspects of the current version require further attention.

1. To me, it does not always become clear which statements are well supported by scientific evidence and which rather reflect the author's opinion on the topic. Often, very broad statements have none or only one reference that does not always fit the statement. One example: In L. 59-61 the authors state, that “[...] VOCs are a fundamental language of soil's hidden networks, and potent chemical signals that alter the physiology and behavior of any organism that detects them 10.” This is a very broad statement, and only one preprint in which the removal of VOCs with anthropogenic origin from soil is discussed, is given as a reference. For such general statements the authors should either provide additional, more convincing references or rephrase the sentences more cautiously. Alternatively, they could explicitly indicate that the remarks represent an opinion rather than a scientific finding.

Other examples are in

L. 76: “VOCs play an important role in plant-plant communication both above and below ground (Fig. 1a) 15.” --> only one reference for a very broad statement (the role of VOCs in belowground plant-plant communication is also highly controversial, see comment no. 3)

L. 88: “[...] VOCs can function as chemical cues or signaling molecules mediating intra- and interspecific plant interactions in the rhizosphere.” --> reference missing

L. 90: “For example, specific root VOCs can inform the health status of a plant (“emitter plant”), resulting in physiological responses in a neighboring plant (“receiver plant”).” --> reference missing

The only example which is given to support this statement is from an unpublished preprint

L. 86: "Root VOCs enable plants to identify their neighbors, adding a layer of complexity to root-root interactions (Fig. 1a)." --> reference missing

L. 244 "Predatory nematodes and mites act as the wolves of the soil, hunting entirely by scent (Fig. 2b)." --> reference missing

2. Closely linked to my first comment: Since it is not always clear which statements present a scientific finding and which reflect the authors' viewpoint, I found it difficult to identify the article's novel claims. Especially, since it has been stated already elsewhere that our knowledge of belowground VOC signaling is limited (eg. Insam and Seewald 2010; Penuelas et al. 2014; Delroy et al. 2016; Wenke et al. 2010, and more). Given that these reviews are ten years old or older the manuscript would benefit from a concise summary of the scientific advances made since their publication. Highlighting the recent scientific progress would help the article distinguish itself more clearly from previously published reviews.

3. Although a perspective article may emphasize a particular viewpoint, I found that the manuscript lacks a balanced discussion of the possibility that VOCs could play only a minor role in soil mediated interactions. For example, in a discussion article published in Science in 2024 by Guerrieri and Rasmann on belowground plant communication (10.1126/science.adk1412), root exudates were hypothesized as the main signaling molecules between plants and their living environment, not VOCs. This is supported, by the (well documented) sink function of soil for VOCs through microbial uptake, which is only briefly mentioned by the authors. A better inclusion of contrasting viewpoints would strengthen the article's credibility and provide readers with a more comprehensive view of the current debate.

4. A figurative language can illustrate complex relationships, however the authors should ensure that their wording is technically accurate and not overly simplified, for example in

L. 244: "Predatory nematodes and mites act as the wolves of the soil, hunting entirely by scent (Fig. 2b). They navigate the tortuous air-filled pores, following faint chemical trails released by their prey 68." Or

L. 276: "Bulk water flow also transports VOCs, and within water, a hidden infrastructure, the contiguous channels formed by roots, mycelia, and burrowing animals, could act as a superhighway for their long-distance travel 79,80."

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Decision Letter:

<*** REMEMBER TO ATTACH REVISIONS CHECKLIST (WORD)***>

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Dear Professor Raza,

Your manuscript titled "The Scented Web: Long-distance VOC-Mediated Conversation in Soil" has now been seen by our reviewers, whose comments appear below. Reviewer 2 was unavailable for the second round of review and was replaced by Reviewer #3, whose comments are included below. In light of their advice we are delighted to say that we are happy, in principle, to publish a suitably revised version in Communications Earth & Environment.

We therefore invite you to revise your paper one last time to address the remaining concerns of our reviewers. At the same time we ask that you edit your manuscript to comply with our format requirements and to maximise the accessibility and therefore the impact of your work.

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We hope to hear from you within two weeks; please let us know if you need more time.

Best regards,

Marisa McDonald, PhD

Associate Editor, Communications Earth & Environment
Consulting Editor, Communications Sustainability

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@commssustain.nature.com

REVIEWERS' COMMENTS:

Reviewer #1 (Remarks to the Author):

The authors have addressed all of my previous comments thoroughly and to my full satisfaction. The revisions have substantially improved the clarity, methodological transparency, and overall quality of the manuscript. I find that the concerns raised in the earlier review have been appropriately resolved, and I have no further remarks at this stage. The study now presents a coherent and well-supported contribution to the field.

I therefore recommend the manuscript for publication in its current form and would like to extend my sincere congratulations to the authors for their careful and constructive revisions.

Reviewer #3 (Remarks to the Author):

The topic of the manuscript to integrate existing research on the role of VOCs in signaling among belowground organisms is timely. Although BVOCs have been studied for decades, the processes occurring specifically in soil remain poorly understood. The limited amount of available research on the role of belowground VOCs is evident in the fact that a single

review article can compile results on both intra- and interspecific signaling, while in-situ studies and the consideration of soil properties in experimental designs are almost entirely absent. The manuscript is clearly written, and the topics are organized in a logical manner. Based on the revisions, the authors' interpretations are now more clearly distinguished from the observations reported in the cited studies; however, the authors' own synthesis and discussion, including critical perspectives, could be still expanded.

The authors have addressed the reviewers' comments well and refined the descriptions of experimental designs presented in the manuscript, thereby increasing the utility of this review article for guiding future research. For example, the lack of in-situ studies in the published literature is clearly evident, highlighting the need to pursue more complex research approaches that better reflect field conditions in order to deepen our understanding of VOC-mediated signaling.

In response to reviewers' comments, authors have clarified the spatial extent of VOC signals reported in studies. However, many times in the text the term "long-distance" is used rather vaguely and would have been specified more precisely in terms of order of magnitude (e.g., millimeter- versus centimeter-scale). In the diffusive movement of gases, transport is effectively limited to millimeters, and considering the high heterogeneity of soil, observations reporting VOC transport over distances of tens of centimeters sounds unrealistic when extrapolated to natural conditions. The manuscript also discusses the chaotic nature of signaling: signals emitted by different organisms under varying stress conditions form a complex blend, making the verification of directed signaling extremely challenging. Empirical data on the transport efficiency and chemical transformation of VOCs remain scarce; nevertheless, a brief discussion of physicochemical properties of VOCs would be valuable, as it would help to create boundaries for the applicability of results obtained under controlled conditions to natural environments.

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Manuscript Number: COMMSENV-26-0816

Title: **The Scented Web: Long-distance VOC-Mediated Conversation in Soil**

Dear Editor

In accordance with your decision, we are pleased to resubmit our manuscript as a perspective. We sincerely thank you and the reviewers for their constructive and insightful comments. These suggestions have been invaluable in improving the quality and clarity of our manuscript. We have carefully revised the manuscript in line with all comments received and provide a detailed, point-by-point response below (in blue).

Reviewer #1 (Remarks to the Author):

Comment: The manuscript argues that VOCs are a “language” structuring belowground interactions across microbes, plants, protists, nematodes, and predators, and it identifies major knowledge gaps (mixtures, perception, multitrophic complexity, environmental modulation, pollutants/microplastics). This is a strong and attractive premise for a perspective. The writing is generally readable and the sectioning is logical. However, the current version sometimes overclaims “long-distance” relevance without sufficiently separating what is well demonstrated in soil/field from what is inferred from microcosms/olfactometers/headspace assays. Several key statements would benefit from (i) more precise language about spatial scale and soil conditions, (ii) explicit limitations of existing approaches, and (iii) inclusion of missing cornerstone studies (including entomopathogenic nematode attraction to synthetic root volatiles).

Response: Thank you very much for your helpful suggestions and valuable input on our manuscript. According to the suggestions, the entire manuscript has been carefully revised to clarify the type of study and conditions to differentiate between *in vitro* studies performed using microcosms/olfactometers/headspace assays and field studies. Moreover, we include sections under each heading to describe the limitations of existing approaches and include suggested cornerstone studies in the revised manuscript.

Comment: A recurring weakness is that many examples come from simplified systems, but the manuscript sometimes reads as if mechanisms are established under realistic soil conditions. More clearly label evidence as *in vitro*/headspace, soil microcosm, mesocosm, or field. Add a short “Reality check” paragraph in each major section addressing: how soil structure, moisture, organic matter, and microbial consumption constrain VOC plumes, how concentration ranges used in assays compare with expected pore-air concentrations.

Response: Thanks, we have now clearly labeled each described study throughout the manuscript as *in vitro*/headspace, soil microcosm, mesocosm, or field. In addition, we have added a short "Reality check" paragraph in each major section that addresses how soil structure, moisture, organic matter, and microbial consumption constrain VOC plumes, and how VOC concentration ranges used in assays are unrealistic compared with expected pore-air concentrations.

Comment: The introduction cites “up to centimeters” and later mentions 50 cm detection by nematodes. These are eye-catching, but risk being perceived as overstated unless contextualized with caveats (soil type, moisture, airflow, experimental setup). Define “long-distance” explicitly (mm vs cm vs tens of cm) and distinguish: diffusion through pore space vs. movement via preferential flow/macropores, detection distance vs. effective ecological influence distance.

Response: Thanks, we have revised the text to clarify the specific experimental conditions used in studies on the long-distance roles of VOCs and to note that these studies relied on artificial systems that reduce the physical constraints typical of natural soil; thus, the reported distances likely represent upper detection limits rather than ecologically representative interaction distances. This information has been added at multiple places in the text where appropriate.

Comment: The predator–prey/nematode sections rely heavily on classic citrus/weevil work and related cues. Two relevant studies are indeed missing and should be cited where you discuss EPN navigation toward synthetic volatiles: Jagodič, Ipavec, Trdan, Laznik (2017) *BioControl* – synthetic volatiles from insect-damaged *Brassica nigra* roots and EPN attraction. Laznik & Trdan (2016) *J. Pest Sci.* – synthetic volatiles emitted by insect-

damaged carrot roots and EPN attraction behaviors. These papers strengthen the manuscript's argument that root-derived (and damage-induced) volatiles can function as navigation cues, and they broaden plant system coverage beyond citrus.

Response: Thanks, we have now included both studies, Jagodič et al. (2017) and Laznik & Trdan (2016), in the relevant section on EPN navigation toward volatiles (lines 306-311) in the revised manuscript.

Comment: The manuscript correctly notes that VOC perception mechanisms are poorly resolved, but the discussion is still quite general. In a perspective, you can be speculative—but you should give readers a clearer map of plausible mechanistic routes in plants vs microbes vs nematodes/protists. Split perception subsection by organism group (plants/bacteria/fungi / nematodes-protists). Add a brief set of “testable predictions” (e.g., membrane perturbation signatures, receptor-like proteins, transcriptomic motifs, mutant phenotypes).

Response: Thanks, we now provide information on potential VOC targets separately for plants, microbes, nematodes, and protists in the revised manuscript (lines 387-398) to give readers a clearer map of plausible mechanistic routes.

Minor comments: Proofread for spacing/typos (e.g., “microbesis”, missing spaces in “Pseudomonasspecies”, inconsistent hyphenation); Several references are repeated (e.g., similar entries appear multiple times); check duplication (e.g., refs 38/44; 45/58 look duplicated in your list). Some citations appear as “Preprint at ...” even when a final journal version may exist—please verify and cite published versions where available. Ensure consistency of “VOCs” vs “BVOCs” terminology in the soil section. Reduce absolute phrasing (“no information is available”)—often it is safer to say “limited information”.

Response: Thanks, we have proofread the entire manuscript to correct spacing and typographical errors (e.g., “microbesis” → “microbes is”, “Pseudomonasspecies” → “Pseudomonas species”). Duplicate references have been removed and the reference list cleaned up (including refs 38/44 and 45/58). Preprint citations have been updated to published versions where available. We have standardized terminology for “VOCs” throughout the soil section for consistency. Finally, absolute phrasing such as “no

information is available" has been replaced with more accurate statements such as "limited information is available." All changes have been made throughout the revised manuscript.

Reviewer #2 (Remarks to the Author):

Comment: In their perspective article, "The Scented Web: Long-distance VOC-Mediated Conversation in Soil", Ali et al. argue that volatile organic compounds (VOCs) are key signaling molecules in belowground interactions among plants, microbes, and other soil organisms. With this, the authors address a relevant and timely topic that is surely of interest to the readers of Communications Earth & Environment. My own scientific expertise lies more in plant physiology and interactions than in soil microbiology and fauna, which is reflected in the focus of my comments. While I believe this manuscript has the potential to make a valuable contribution to the discussion of the ecological relevance of soil VOCs, several aspects of the current version require further attention.

Response: Thank you very much for your helpful suggestions and valuable input on our manuscript. According to the suggestions, the entire manuscript has been carefully revised.

Comment: To me, it does not always become clear which statements are well supported by scientific evidence and which rather reflect the author's opinion on the topic. Often, very broad statements have none or only one reference that does not always fit the statement. One example: In L. 59-61 the authors state, that "[...] VOCs are a fundamental language of soil's hidden networks, and potent chemical signals that alter the physiology and behavior of any organism that detects them 10." This is a very broad statement, and only one preprint in which the removal of VOCs with anthropogenic origin from soil is discussed, is given as a reference. For such general statements the authors should either provide additional, more convincing references or rephrase the sentences more cautiously. Alternatively, they could explicitly indicate that the remarks represent an opinion rather than a scientific finding.

Response: Thanks, we have carefully revised the manuscript to clearly distinguish well-supported statements from interpretive or opinion-based remarks. For broad claims, we have either (1) added multiple strong references that directly support the statement, (2) rephrased more cautiously (*e.g.*, "VOCs are proposed to function as..." instead of "VOCs are a fundamental language..."), or (3) explicitly indicated where a remark represents our perspective. The specific example on lines 59-61 has been revised to cite appropriate, peer-reviewed evidence rather than a single preprint. These changes have been made throughout the revised manuscript.

Comment: Other examples are in L. 76: "VOCs play an important role in plant-plant communication both above and below ground (Fig. 1a) 15." --> only one reference for a very broad statement (the role of VOCs in belowground plant-plant communication is also highly controversial, see comment no. 3) L. 88: "[...] VOCs can function as chemical cues or signaling molecules mediating intra- and interspecific plant interactions in the rhizosphere." --> reference missing L. 90: "For example, specific root VOCs can inform the health status of a plant ("emitter plant"), resulting in physiological responses in a neighboring plant ("receiver plant"). " --> reference missing. The only example which is given to support this statement is from an unpublished preprint L. 86: "Root VOCs enable plants to identify their neighbors, adding a layer of complexity to root-root interactions (Fig. 1a)." --> reference missing L. 244 "Predatory nematodes and mites act as the wolves of the soil, hunting entirely by scent (Fig. 2b)." --> reference missing.

Response: Thanks, we have carefully revised the whole manuscript. For L. 76, we have rephrased the statement about plant-plant communication more cautiously and added multiple references, including studies that highlight the controversial nature of belowground VOC-mediated signaling. For L. 86, 88, and 90, we have added missing references; where only a preprint was available, we have either supplemented with peer-reviewed work or reworded the statement to reflect the preliminary evidence. For L. 244, we have added a citation supporting the role of scent in predatory nematode and mite foraging, while slightly softening the analogy to indicate it reflects current understanding

rather than established fact. All broad claims now include appropriate supporting citations or are explicitly framed as interpretations where evidence is limited. These changes have been made throughout the revised manuscript.

Comment: Closely linked to my first comment: Since it is not always clear which statements present a scientific finding and which reflect the authors' viewpoint, I found it difficult to identify the article's novel claims. Especially, since it has been stated already elsewhere that our knowledge of belowground VOC signaling is limited (eg. Insam and Seewald 2010; Penuelas et al. 2014; Delroy et al. 2016; Wenke et al. 2010, and more). Given that these reviews are ten years old or older the manuscript would benefit from a concise summary of the scientific advances made since their publication. Highlighting the recent scientific progress would help the article distinguish itself more clearly from previously published reviews.

Response: Thanks, we agree that the manuscript did not always clearly distinguish established findings from our own perspective, nor did it sufficiently highlight recent advances. To address this, we have revised the manuscript. These advances include improved analytical methods for soil VOC detection, identification of specific VOC signals in rhizosphere interactions, and emerging evidence for VOC-mediated behaviors in soil fauna. Throughout the manuscript, we now more clearly flag novel claims as our perspective while grounding established findings in appropriate citations. This revision helps distinguish our contribution from previous reviews and clarifies where the field has progressed.

Comment: Although a perspective article may emphasize a particular viewpoint, I found that the manuscript lacks a balanced discussion of the possibility that VOCs could play only a minor role in soil mediated interactions. For example, in a discussion article published in Science in 2024 by Guerrieri and Rasmann on belowground plant communication (10.1126/science.adk1412), root exudates were hypothesized as the main signaling molecules between plants and their living environment, not VOCs. This is supported, by the (well documented) sink function of soil for VOCs through microbial uptake, which is only briefly mentioned by the authors. A better inclusion of contrasting

viewpoints would strengthen the article's credibility and provide readers with a more comprehensive view of the current debate.

Response: Thanks, we agree that the manuscript originally leaned too heavily toward promoting the role of VOCs without adequately discussing alternative views or the limitations that might make VOCs only minor players in certain contexts. To address this, we acknowledge in the revised manuscript that most studies are conducted in controlled environments and that the concentrations and activity ranges of VOCs described likely represent upper detection limits rather than ecologically representative interaction distances. Moreover, we include a statement that there is also a viewpoint that VOCs play a minor role in soil, given soil's sink functions for VOCs through microbial uptake and methodological challenges in translating controlled environment findings to field conditions.

Comment: A figurative language can illustrate complex relationships, however the authors should ensure that their wording is technically accurate and not overly simplified, for example in L. 244: "Predatory nematodes and mites act as the wolves of the soil, hunting entirely by scent (Fig. 2b). They navigate the tortuous air-filled pores, following faint chemical trails released by their prey 68." Or L. 276: "Bulk water flow also transports VOCs, and within water, a hidden infrastructure, the contiguous channels formed by roots, mycelia, and burrowing animals, could act as a superhighway for their long-distance travel 79,80."

Response: Thanks. We have revised overly figurative or technically imprecise language throughout the manuscript. These revisions maintain clarity while ensuring technical accuracy.

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Title: Volatile organic compound-mediated conversation in soil

Dear Editor

In accordance with your decision, we are pleased to resubmit our manuscript as a perspective. We sincerely thank you and the reviewers for their constructive and insightful comments. These suggestions have been invaluable in improving the quality and clarity of our manuscript. We have carefully revised the manuscript in line with all comments received and provide a detailed, point-by-point response below (in blue).

Reviewer #1 (Remarks to the Author):

The authors have addressed all of my previous comments thoroughly and to my full satisfaction. The revisions have substantially improved the clarity, methodological transparency, and overall quality of the manuscript. I find that the concerns raised in the earlier review have been appropriately resolved, and I have no further remarks at this stage. The study now presents a coherent and well-supported contribution to the field. I therefore recommend the manuscript for publication in its current form and would like to extend my sincere congratulations to the authors for their careful and constructive revisions.

Response: We thank the reviewer for the positive assessment and constructive feedback. We are pleased that the revisions have addressed all concerns and improved the clarity and quality of the work.

Reviewer #3 (Remarks to the Author):

The topic of the manuscript to integrate existing research on the role of VOCs in signaling among belowground organisms is timely. Although BVOCs have been studied for decades, the processes occurring specifically in soil remain poorly understood. The limited amount of available research on the role of belowground VOCs is evident in the fact that a single review article can compile results on both intra- and interspecific signaling, while in-situ studies and the consideration of soil properties in experimental designs are almost entirely absent. The manuscript is clearly written, and the topics are organized in a logical manner. Based on the revisions, the authors' interpretations are now more clearly distinguished from the observations reported in the cited studies; however, the authors' own synthesis and discussion, including critical perspectives, could still be expanded. The authors have addressed the reviewers' comments well and refined the descriptions of experimental designs presented in the manuscript, thereby increasing the utility of this review article for guiding future research. For example, the lack of in-situ studies in the published literature is clearly evident, highlighting the need to pursue more complex research approaches that better reflect field conditions in order to deepen our understanding of VOC-mediated signaling.

Response: Thanks for the positive comments.

In response to reviewers' comments, authors have clarified the spatial extent of VOC signals reported in studies. However, many times in the text the term "long-distance" is used rather vaguely and would have been specified more precisely in terms of order of magnitude (e.g., millimeter- versus centimeter-scale). In the diffusive movement of gases, transport is effectively limited to millimeters, and considering the high heterogeneity of soil, observations reporting VOC transport over distances of tens of centimeters sounds unrealistic when extrapolated to natural conditions.

Response: The long-distance diffusion of root VOCs has been reported up to 12 cm to attract beneficial bacteria and up to 50 cm to attract nematodes. However, both studies were conducted under controlled conditions. We have revised the order of magnitude, like "millimeter to centimeter scale" in the revised manuscript at line 64.

The manuscript also discusses the chaotic nature of signaling: signals emitted by different organisms under varying stress conditions form a complex blend, making the verification of directed signaling extremely challenging. Empirical data on the transport efficiency and chemical transformation of VOCs remain scarce; nevertheless, a brief discussion of the physicochemical properties of VOCs would be valuable, as it would help to create boundaries for the applicability of results obtained under controlled conditions to natural environments.

Response: The physicochemical properties of VOCs are provided in the revised manuscript at lines 60-64. We have also included a few lines on the effects of VOCs' physicochemical properties and their diffusion at lines 325-328.