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Interactive comment on "The soil fertility and leaf nutrient status in enset gardens in different altitude zones of the Gamo highlands, Ethiopia and inferences for Xanthomonas wilt prevalence" *by* Sabura Shara et al.

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The authors would like to thank Reviewer 1 for his/her very detailed and comprehensive report and annotated text, which will help us considerably in improving the manuscript. Kindly find our answers (AC) to the comments (RC1) below, along with proposed changes to the manuscript.

General Comments

RC1: "Unfortunately, there appears to be many confounding effects, which impact on

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the results and the conclusions made by the authors". AC: Yes, this is correct and could not be avoided in an observational study such as this one. Hence, we mentioned it clearly in the discussion (line 396) and conclusion (line 417). Manuscript changes: we will also add a line to the abstract, specifically addressing confounding between soil properties and altitude.

RC1: While the authors surveyed 276 enset gardens, they based their conclusions on the results from 11 sites, those at lower elevations that had corresponding disease assessment and soil physicochemical data. AC: This is only partly correct, as the paper has two aims (line 90-93): (i) a soil fertility assessment and (ii) examining potential correlations of soil and altitude with Xantomonas prevalence, as to gain some insight in the ecological niche of the pathogen. With regard to the first objective, the number of sampled farms is 40 (table 1 and 2; first part of the conclusion, line 419-414). With regard to the second objective, disease prevalence was related to altitude in 276 farms (table 4, conclusion line 414) and to soil properties in 40 farms (table 5). As soil properties and altitude are confounded, we also assessed the zone with the highest incidence separately (11 farms, table 6, line 415 in the conclusion). Manuscript changes: the number of farms for each assessment is clearly indicated with each table. However, we agree with the reviewer that it is unclear in the conclusion. Hence, we will remove 'in 276' from line 409 and we will remove pH and K in line 414-415 and in the abstract, as those indeed are only based on a small number of farms.

RC1: Would it be possible that these organic fertilizers were also sources of EXW inoculum adding to reinfection of plants? AC: Although no specific information for EXW is available, other strands of Xantomonas are considered to be eliminated during the composting process (e.g. Elorrieta et al., 2003 in Agriculture, Ecosystems and the Enviornment https://doi.org/10.1016/S0167-8809(02)00170-6). We therefore did not consider it as a potential source for inoculum in this study. Manuscript changes: At line 397 we will add the following information: "An alternative explanation is that the organic composts used to fertilize the garden may be a source of inoculum for EXW and hence

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explain the correlation between certain soil nutrients and EXW incidence. Yet, although no specific information is available for EXW, other Xanthomonas species have been reported to be heat-sensitive and easily eliminated during composting (Elorrieta et al., 2003).

RC1: Much of the physicochemical data is not significantly different from one another, there is no clear discrimination between sites and there is insufficient statistical power to agree with the conclusions made by the authors. AC: As this is an on-farm observational study on a crop that has received very little attention in international literature, and given the current lack of standardization of management in Enset farms, it can't be avoided that not all studied variables proved statistically different between sites. However, we were very careful only to focus on statistically significant differences in the discussion and conclusion.

RC1: Currently the manuscript is confusing with some terms like "inner-outer", which are difficult for the reader to follow. Furthermore, there is inconsistent use of tense, with the manuscript changing between past and present tense. This should be revised so that there is consistent use of past tense English. The inclusion of commas needs to be reviewed throughout the manuscript. AC: Thank you for the very detailed annotation and linguistic mistakes pointed out. They are noted and will be corrected. Manuscript changes: all annotations will be reviewed and we will send the paper for editing to a linguist.

Specific Comments

Abstract

RC1. This is a summary of what was done and therefore should be in past tense. e.g. increase → increased, are → were etc. AC/Manuscript changes: will be adapted and reviewed by a linguist.

RC1: L28 The authors make a "throw-away" statement that, "enset gardens should be

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optimized in relation to agro-ecological conditions and that both elevation and soil nutrient status need to be considered. . .. . .". It would be better if the authors were able to elucidate what these optimum conditions were to reduce EXW and not leave the readers wondering what these conditions were? AC: This statement indeed is somewhat obvious. What we want to say is that there are no optimum nutrient recommendations available in literature for Enset, and that, from the data, we can see that currently organic inputs are not used effectively, hence the need for optimization. To achieve such recommendations, additional agronomical trials are necessary. Manuscript changes: The sentence will be adapted to: "We conclude that fertility management in enset gardens is currently not optimized and... "

Introduction

RC1: The introduction needs to be reviewed to make it more concise with information relevant to the study. Currently there is a lot of superfluous information which does not add to the argument being developed in the manuscript. AC: Noted. Manuscript changes: the introduction will be rewritten to make it more concise

RC1: L37 Food security is a main target or is a target? AC/Manuscript changes: adapted to 'a target'.

RC1: L50 fibre not fiber. AC/Manuscript changes: adapted as suggested.

RC1: L53 greater of higher? AC/Manuscript changes: higher.

RC1: L55-56 How does the dense leaf canopy reduce land degradation and sequester carbon? AC: A high canopy cover reduces raindrop impact, interrill erosion and rill erosion (cfr. the Universal Soil Loss Equation) and reduces carbon losses due to erosion. It also provides shade which reduces soil temperature and therefore decomposition rate of organic carbon in the soil. The sentence was adapted and a reference was added. (Lal R., 2003. Environment International 29, 437-450; DOI: 10.1016/S0160-4120(02)00192-7). Manuscript changes: Sentence changed to : "Moreover, the dense

leaf canopy is an asset in reducing soil erosion and in sequestering carbon (Lal, 2003)."

RC1: L58 Remove 'Due to limited genetic research'. AC/Manuscript changes: adapted as suggested.

RC1: L62-64 These sentenced should be reviewed to be more concise. AC/Manuscript changes: Sentence changed to "The yield and economic competitiveness of the enset systems is limited by poor soil fertility management and bacterial wilt disease. Enset typically grows on weathered tropical soils, and animal manure and compost from household refuse are used as soil amendments."

RC1: L72 Remove wreaking havoc. AC/Manuscript changes: adapted to "is causing significant damage".

RC1: L82-85 Is this sentence necessary, does it add anything to the argument being developed? AC/Manuscript changes: Yes, but we changed 'Also, ...' on line 85 to 'More specifically, ...' .

RC1: L88-100 The paragraph outlining the aims and hypothesis needs to be reviewed to make both the hypothesis and aims of the study clearer for the reader. AC/Manuscript changes: Adapted to "We therefore hypothesize that an insight into soil-plant-pathogen interactions might yield a complementing path for disease control in enset systems as well. Using an on-farm observational approach, the aim of this study was to contribute to food security and livelihood improvement of enset dependent farm households by (i) assessing gradients in soil properties between enset gardens, between the garden and the surrounding fields and whitin the garden, (ii) relating variation in soil nutrients relates to leaf nutrient status, (iii) by surveying prevalence and distribution of EXW symptomatic enset gardens prevalence of enset EXW in enset gardens and (iii) to relate the distribution of symptomatic gardens to altitude and soil and plant nutrient levels"

Materials and methods

RC1: L110-113. Is the description of bedrock required? AC: Yes, because it is important to understand soil properties later in the manuscript. Manuscript changes: 'bedrock' was changed to 'parent material' to make this more clear.

RC1: L153-154 Dates are confusing. AC/Manuscript changes: Adapted to "Observations were made between June 2016 and March 2017".

RC1: L159 A mixed soil sample... is a confusing sentence that requires reviewing. AC/Manuscript changes: Adapted to "Four bulk soil samples were taken and combined in one composite bulk sample per fertility zone and ... ".

RC1: L202 computed not compute . AC/Manuscript changes: Adapted as suggested.

RC1: L211 of is repeated. AC/Manuscript changes: Adapted as suggested.

RC1: L212-214 It is unclear what this sentence is trying to explain. Needs revision. AC/Manuscript changes: see next comment.

RC1: L211 The number of points on a positive side of the PCA diagram is 64.7%, which means that 35.3% were on the negative side, which does not give a lot of confidence that there is nothing more than chance to where the points occur on the PCA biplot. And RC1: Fig 3 There are no obvious groupings in the PCA diagram. If 95% confidence intervals were placed around elevation or symptomatic gardens there would be a lot of overlap. AC: We used the PCA analysis for exploratory procedure (see line 194), i.e. to get a grip on what explains most of the variation in the dataset and to identify interrelationships among the variables. It shows that most soil nutrients are related (vectors aligned positively along PC1) and that high values for these nutrients imply low values of Al. Moreover, it shows that the variation related to soil nutrient is independent (ortognoal) to soil texture. Subsequently, ANOVA, Mixed models and t-tests were used to establish significant differences. Manuscript changes: To make this more clear, the purpose of the PCA analysis will be mentioned more clearly in the masucript as stated above. We will also confirm if the altitude of the plots and the scores on PC1 and PC2

are significantly correlated and describe relations accordingly.

RC1: The analysis and presentation of the results used should be reviewed to develop a minimum data set that discriminates between the sites and consider the use of box and whisker plots to show how much overlap and variation there is between the different categories. AC: This information is in table 1. Putting it into graphs would aid interpretation, but would also result in a very large number of graphs.

RC1: Table 1 The table is difficult to read and understand as it is presented. Consider using horizontal lines to separate each variable. There is inconsistent placement of the soil property title either in the middle or in centre. AC/Manuscipt change: Adapted as suggested: a horizontal line drawn between each variable and the soil properties are consistently placed in the middle. Non-significant differences denoted by ns.

RC1: Consider using ns to denote non-significant difference between elevation categories. This applies to all tables in the manuscript. AC/Manuscipt change: Adapted as suggested.

RC1: L243 the description of the zones is very confusing. This should be revised and consistently use throughout the manuscript. AC/Manuscipt change: Noted. We will address the description of the zones in the materials and methods section to make it more concise and check the consistent use of terms throughout the manuscript.

RC1: Table 2 Consider using ns to denote non-significant difference between elevation categories. AC/Manuscipt change: Adapted as suggested.

RC1: L258-266 This section is very confusing, and I am not sure what it is trying to explain. Is it necessary for the data presented within the manuscript? AC: The main message of this section is that the difference in soil nutrient levels is not reflected in a difference in leaf nutrient levels, except for N (lines 254-256; Table 3). The information that follows (line 257-266 and figure S1) is not considering fertility zones, but wants to explain that despite high levels of soil nutrients, several (micro)nutrients may be

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deficient in the plant. Table S1 refers to a bigger dataset than the farms that we have nutrient content for, but as there is very little information about Enset leaf nutrient status available in literature, we decided to add it as supplementary information. We consider this information important for future agronomical research and recommendations, but we agree that the current formulation is confusing. Manuscript changes: we will adapt the formulation of lines 257-266 accordingly.

RC1: Table 3 Consider using ns to denote non-significant difference between elevation categories. AC: Accepted. The differences outlined in table 3 are between garden zones, not elevation categories. Manuscipt change: we will use ns to denote non-significant differences between garden zones and adapt the table caption to make this more clear.

RC1: Table 3 Does the leaf data add much to the argument? AC: One of the main aims of the paper (line 90-93) is a fertility assessment. As there are no standard values or critical ranges described in literature for Enset, we consider this important information for future agronomical research and recommendations.

RC1: L278-280 This sentence is unclear and requires revision. AC/Manuscipt change: the sentence can be dropped from the manuscript.

RC1: L288-289 This method is not convincing for discrimination between symptomatic and asymptomatic gardens. AC/Manuscript change: vide supra (comment on L211): we will use the same approach to see if the factor scores on PC1 and PC2 of symptomatic gardens differ significantly from asymptomatic ones.

RC1: Table 5 Consider using ns to denote non-significant difference between elevation categories. AC: Accepted. The differences outlined in table 5 are between symptomatic and asymptomatic gardens, not elevation categories. Manuscipt change: we will use ns to denote non-significant differences between symptomatic and asymptomatic gardens and adapt the table caption to make this clearer.

RC1: Table 6 It would appear that the entire sample size being used in this table is 11 gardens. How many were symptomatic and how many asymptomatic of EXW? 11 gardens is not a large enough sample size to be meaningful, when 276 were included in the original survey. This would mean that the results are being extrapolated from only 4% of the gardens included in the survey. Table 6 should be seen in relation to table 5. Soil properties were measured in 40 gardens to compare symptomatic and non-symptomatic gardens (table 5). The table shows that available P and Ca are significantly different between the two. However, if you would split them up into elevation categories, differences are mainly evidenced in the lower elevation zone. This is why we added table 6, which is a subset of table 5. (7 symptomatic and 4 non-symptomatic gardens). Manuscript changes: the number of symptomatic and non-symptomatic gardens will be added in the heading of the table in table 5. Also, we will expand table 6 to include the data of all elevations (also the middle and upper one) – total of 40 farms – and move it to supplementary materials.

RC1: Table 7 Consider using ns to denote non-significant difference between elevation categories. AC: Accepted. The differences outlined in table 7 are between symptomatic and asymptomatic gardens, not elevation categories. Manuscipt change: we will use ns to denote non-significant differences between symptomatic and asymptomatic gardens and adapt the table caption to make this clearer.

Discussion

RC1: Review the use of tense throughout the discussion. E.g. are → were. AC/Manuscript change : Noted, the manuscript will be adapted and reviewed by a linguist.

RC1: L342-343. The authors suggest that “continual application of manure and organic waste . . .” is responsible for changes in soil nutrient levels. Could the organic waste also be contributing to EXW? If contaminated by-products are disposed into gardens in close proximity to houses there may be an increasing amount of inoculum that is

associated with increase in nutrient levels? AC: Although no specific information for EXW is available, other strands of Xantomonas are considered to be eliminated during the composting process (e.g. Elorrieta et al., 2003 in Agriculture, Ecosystems and the Enviornment https://doi.org/10.1016/S0167-8809(02)00170-6). We therefore did not consider it as a potential source for inoculum in this study. Manuscript changes: At line 397 we will add the following information: "An alternative explanation is that the organic composts used to fertilize the garden may be a source of inoculum for EXW and hence explain the correlation between certain soil nutrients and EXW incidence. Yet, although no specific information is available for EXW, other Xanthomonas species have been reported to be heat-sensitive and easily eliminated during composting (Elorrieta et al., 2003).

RC1: L352 The authors indicated that soil nutrients were greater than anticipated. The differences in soil nutrients due to proximity from the house is the main outcome from this study and could be expanded with greater analyses showing differences in nutrients due to garden zones. AC: The garden zones are actually distance classes to the house, so they reflect proximity to the house. Manuscript changes: line 155-159 will be rewritten to make this more clear.

RC1: L356 "liming effect" or neutralising effect? AC: The term 'liming effect' is commonly used in literature to denote the effect of organic residues on raising soil pH (e.g. Mokolobate et al. 2002 in Biology and Fertility of Soils; 10.1007/s00374-001-0439-z).

RC1: L364-367 The authors suggest that foliar nutrients were excessive based on limited literature? Was there any productivity measures that would support that productivity had plateaued with the increase in leaf nutrient levels or is this purely speculative due to lack of data? AC/Manuscript change: The manuscript does not state that the foliar nutrients were excessive, only that there is a lack of variation between foliar nutrient levels. This statement is evidenced in our own data. We assume that the confusion is caused by the use of 'enset gardens' on line 361. We propose to change that to 'enset garden soils' instead.

AC: Observed soil nutrient levels were very high as compared to values for Ethiopia mentioned in literature (see line 353 for references), and to the outfields. Also, if an increase in soil nutrients is not mirrored in an increase in foliar nutrients (hence: plant uptake) it can be considered a sign of inefficient soil nutrient management. Manuscript change: We will add following information to line 366: " (...) status. If an increase in soil nutrients is not mirrored in an increase in foliar nutrients, it can be considered a sign of inefficient plant nutrient uptake and therefore non-optimal soil nutrient management. Hence (...)".

Conclusion

RC1: It is hard to agree with the conclusion as some of the statements are misleading, such as 276 gardens used in the study. While 276 may have been used in the study the conclusions are based on 4% of these sites, only 11, which would appear to be insufficient to be a robust number to draw conclusion of the physicochemical properties that lead to EXW. The authors acknowledge there are many confounding effects in the study which could lead to differences in disease incidence and with only 11 sites on which the physiochemical results are based on, it does not give the reader a lot of confidence in the findings from the survey. AC: This is only partly correct, as the paper has two aims (line 90-93): (i) a soil fertility assessment and (ii) examining potential correlations of soil and altitude with Xantomonas prevalence, as to gain some insight in the ecological niche of the pathogen. With regard to the first objective, the number of sampled farms is 40 (table 1 and 2; first part of the conclusion, line 419-414). With regard to the second objective, disease prevalence was related to altitude in 276 farms (table 4, conclusion line 414) and to soil properties in 40 farms (table 5). As soil properties and altitude are confounded, we also assessed the zone with the highest incidence separately (11 farms, table 6, line 415 in the conclusion). Manuscript changes: the number of farms for each assessment is clearly indicated with each table. However, we agree with the reviewer that it is unclear in the conclusion. Hence, we will remove 'in 276' from line 409 and we will remove pH and K in line 414-415 and in the abstract,

as those indeed are only based on a small number of farms.

RC1: L414 less instead of lower. AC/Manuscript changes: adapted as suggested.

Suggestions

RC1: There appears to be four elements to this study o Disease incidence of EXW o Nutrient status of enset gardens ïC ÌĄ g ÌĘ With elevation ïC ÌĄ g ÌĘ With distance from houses o Leaf nutrient status of enset These could be analysed separately. AC: That is correct. They were analysed in separate paragraphs (nutrient status with elevation in 3.1, nutrient status with distance from the house in 3.2; leaf nutrient status in 3.3 and disease incidence of EXW in 3.4). However, as literature suggests nutrient levels and elevation can influence EXW incidence, we also combined the data in sections 3.5. We made a change to the introduction to make this clearer (see the comment on L88-100).

RC1: To me, the most interesting aspect of this study is how soil nutrients levels change with distance from the houses. This could be teased out further and reanalysed to determine groups or trends across a gradient from the house? AC: As many enset gardens are relatively small (about 0,5 ha) we did not consider it relevant to divide the garden into more than 2 zones. Manuscript changes: We will add information about the average size of an enset farm to the Materials and Methods section.

RC1: The manuscript needs to be revised to improve clarity and conciseness throughout. More care is required in the grammar, particularly the use of past tense and the use of commas. AC/MC: Noted, the manuscript will be adapted and reviewed by a linguist.

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