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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 2 for his/her detailed report and many very relevant remarks. The reviewer very accurately points out the main challenges we experienced with studying an 'orphan crop' as Enset, with limited scientific literature available to this day. Kindly find our answers (AC) to the comments (RC2) below, along with proposed changes to the manuscript.

General Comments



RC2: This manuscript reports an observational study on soil fertility, leaf nutrient content, and Xanthomonas wilt disease incidence in enset gardens of the Ethiopian Gamo highlands in three different altitude zones. In general, the authors found that fertility levels in gardens were higher than in surrounding outfields, increased with deceasing the distance from the house in the garden, and tended to increase with decreasing elevation; except for N, nutrient contents of leaves and soils were not correlated; and disease incidence increased with decreasing elevation. The topic is relevant for the region because of the importance of enset for food security in Ethiopian highlands. In general, the manuscript is clearly written, well structured, and contains observational data that may be technically useful for local farmers and land managers. At the same time, the study lacks crop yield data (...) AC: That is a very good comment, and it reflects a major nemesis in enset research: as enset plants are not grown for their fruit bunches, it is very complicated to establish 'crop yield'. No widely accepted method is available in literature. The plant is processed into various products (fermented pulp bread called 'kocho' , boiled corm or 'amicho', starch porridge or 'bulla', fibres, ...with losses at each step) and leaves are harvested continuously as cattle feed. Moreover, plants are harvested whenever they are needed, not at a predetermined age. Finally, plants in an enset garden are of different varieties and planting (and transplanting) dates. As farmers do not tend to keep records of when they planted which plant and there is no straightforward way to determine plant age, it is not relevant to compare plant biomass or other growth parameters within or between gardens. Moreover, growth varies between varieties, but it is often impossible to correctly identify different varieties in the field as most of them are landraces rather than standardized breeds and not scientifically described. We therefore did not include the complicated issue of crop performance or yield in this paper, but are preparing a separate, follow-up manuscript on how to measure crop response to management in enset gardens, based on controlled field trials.

RC2: At the same time, the study lacks (...) important details on management practices (e.g., amount and form of nutrients added to soils), which make it hardly useful

to develop general strategies to improve crop production, enhance soil sustainability, and fight plant diseases. AC: Again, this is a very appropriate remark referring to yet another difficult aspect of enset research. We did interviews to learn about the management practices in all 276 visited farms. However, as there is no guide for good practices or extension material available to the farmers, we observed a large variability in practices between farms. Describing it into detail would again require a separate manuscript. The only consistent aspect in every visited garden is that plants further away from the garden receive less inputs (typically a bamboo basket (ca. 10 kg) of composted plant waste and cattle manure per 1-3 enset plants per year, depending on the amount of land and cattle a family has) while plants near the house receive inputs almost continuously. Manuscript changes: we will add this information to the materials and methods section.

RC2: Also because of the observational nature of the study and sampling strategy, it fails to provide clear new insights into processes and mechanisms related to enset nutrition and Xanthomonas wilt disease, in as much as the effects of the soil fertility variables and elevation on disease cannot be not separated. AC: To the best of our knowledge, the contrast between the garden zones has not been described in literature before. Moreover, the link between altitude and Xantomonas diseases in members of the banana family remain an issue of debate, and no data on the effect of nutrient levels on bacterial wilt diseases in Enset is available. As establishing field trials with perennial plants is costly and time consuming, this observational study -that combines data from a large area and different landscape positions- was necessary to gain enough insight in the problem to be able to design targeted experimental trials (as suggested in line 416). Based on the data reported in this manuscript we established four experimental sites, and we hope to report the results in the near future.

Specific comments and technical corrections

RC2: L. 42. Is "(Welw.) Cheesman" needed here? AC: Technically, full scientific names of plants require mentioning the author, so we added that information the first time we



mention the plant in the manuscript.

RC2: L. 51-53. "The major food..." This sentence seems to be irrelevant for the present study and should be removed. AC/manuscript changes: we will remove the Ethiopian names of the product but will mention that the the processed pseudostem and corm are consumed rather than the fruit, to highlight the difference with better known members of the banana family.

RC2: L. 58- 59. "Due to limited genetic research, there is also no widely adopted nomenclature for enset varieties." Again, this sentence seems to be irrelevant for the study. AC/manuscript changes: We will remove "due to limited genetic research" but keep the rest of the sentence as it explains why we are only able to give a local name for the variety described in this study (e.g. line 163)

RC2: L. 67- 70. The authors state that there are no recommendations on nutrient management for enset. I do not have access to the full text of the references provided here by the authors (Amede and Taboge, 2007; Elias et al., 1998; Uloro and Mengel, 1994), but they do seem to deal with nutrient management for enset. The present manuscript describes an observational study, and thus the optimal nutrient requirements of enset remain unresolved (L. 366-367). AC: It is correct that the papers mentioned deal with nutrients in observational (Amede and Taboge, 2007; Elias et al., 1998) and experimental (Uloro and Mengel, 1994) studies on Enset nutrient requirements. They however state that more research is required, notably per agro-ecological zone. Hence the current study. More experimental research is indeed required to resolve the issue further, as stated on line 416. Manuscript changes: we mean that there are no official/generally accepted recommendations or extension materials available to enset farmers in the region. We will change the section accordingly to make this clearer.

RC2: L. 84. Remove "and." AC/manuscript changes: adapted as suggested (line 83).

RC2: L. 91. Specify here which agroecological zones you are referring to. AC/manuscript changes: we refer to elevation zones, which will be added to the text.

RC2: L. 97. Change “further” to “farther”. AC/manuscript changes: adapted as suggested.

RC2: L. 98. I suggest revising to “the relationship between soil properties, leaf nutrient contents, and affected farms was investigated.” AC/manuscript changes: adapted as suggested.

RC2: L. 99-100. This sentence is redundant and can be removed. AC/manuscript changes: adapted as suggested.

RC2: L. 105. Change to “state of Ethiopia, between 6...” AC/manuscript changes: adapted as suggested.

RC2: L. 112-113. Provide a reference for the soil classification system used. AC/manuscript changes: we used World Reference Base for Soil Resources, version 2015. We will add the reference.

RC2: L. 117-120. The zones below 2000 and above 3000 m were not addressed in the study. Why? AC: In the study area, there are nearly no enset farms below 2000 m or above 3000m.

RC2: L. 126. Why these particular sample sizes? Provide the total number of households and gardens in the zones. AC: Sample sizes are a consequence of the number of households we found that were willing to participate in the study. We aimed to have a comparable number of farms in each elevation zone. Moreover, we added additional farms in the highest elevation zone, as the relative number of symptomatic farms is much lower there. We were not able to report on the total number of households/garden in each zone, as these data are only available per ‘kebele’ (smallest administrative unit in Ethiopia). However, a kebele typically does not coincide with a single elevation zone.

RC2: L. 127. Are there inter-varietal differences? This information should be provided if available. The authors mention in the Introduction that previous studies have reported inter-varietal differences in the level of tolerance to Xanthomonas wilt disease. AC:



Literature indeed have reported differences in their tolerance to EXW, although none is resistant. Inter-varietal differences on leaf nutrients are not well studied. The main problem is that most varieties are landraces rather than standardized breeds and have only local names that moreover differ between communities (the same variety often has a different name in different villages). Hence, it was often impossible to compare the names of the varieties in our study area to the names of varieties mentioned in the literature (local farmers didn’t recognize most of the names mentioned in literature, nor could we find our local variety names in literature). On top of that, not all varieties can be accurately distinguished in the field. Hence, we decided not to consider inter-varietal differences in this study.

RC2: L. 131. “it was difficult to exactly quantify...” How did this difficulty affect the results? AC: as stated on line 131, we decided not to quantify disease incidence (number of plants affected by the disease) as this cannot accurately be done (it is recommended to remove diseased plants, but farmers don’t keep records of how many plants they removed during a certain time period). Instead, we decided to use presence/absence data, i.e. if the farm had symptomatic plants or not during the study period and in the last five year. Manuscript changes: we will state this more clearly in the manuscript.

RC2: L. 157. Change to “two fertility zones: inner (IR) and outer zone (OR)” Why are these two zones called “fertility” zones? AC/manuscript changes: adapted as suggested. We propose to change ‘fertility zones’ to ‘garden zones’ in the manuscript to avoid confusion.

RC2: L. 160. Did you take 40 samples per elevation zone? Please clarify. AC: we sampled 40 gardens. In each garden we took a composite sample per garden zone (2 samples per garden, so a total of 80 in the infields). Additionally, we took 28 samples in the outfields, as not all gardens had outfields (some were neighboring other gardens). Manuscript changes: we will add a table to the supplementary information further clarifying the soil and plant sampling techniques

RC2: L. 163. Why 19? AC: Within the 40 gardens that were intensively sampled for soil nutrients, only 19 had plants of the selected variety (Maze) of a comparable age in both garden zones (IR) and (OR). Manuscript changes: we will add the rationale behind the sampling to the manuscript.

RC2: L. 155-170. The sampling strategy is complex and I found this text a bit difficult to follow. For the sake of clarity, I suggest providing a supplementary table summarizing the number of plant and soil samples, gardens, zones and households. AC/manuscript changes: This indeed is a very good idea to improve clarity. We will adapt as suggested.

RC2: L. 183. Why didn't you analyze other nutrients (e.g., Cu, Zn. . .)? AC: We measured those only in plant samples, not in soil samples. This is because the nutrients mentioned on line 183 can all be measured in the same ammonium lactate extract for soil samples, while analyzing the others would require a lot of additional extractions and lab expenses. Hence, as the PCA showed that most soil nutrients are strongly correlated, we decided to focus our limited resources on other aspects of the study.

RC2: L. 185. "by elemental analysis" is redundant. Please reword. AC/manuscript changes: changed to 'total combustion'.

RC2: L. 200-201. What test did you used for heteroscedasticity? Were normality assumptions checked and tested? AC: Levene's test was used to test for heteroscedasticity. Shapiro-Wilk test and the Normal Quantile plot were used to check normal distribution. Data were log-transformed if necessary.

RC2: Figure 3. Axis labels are too small. AC/manuscript changes: adapted as suggested.

RC2: L. 227-228. ". . . with ranges from 31.8 to . . ." These ranges are provided in Table 1 and not needed here. AC/manuscript changes: removed as suggested.

RC2: Table 1. I suggest providing only the most relevant information in a figure, raw



data as supplementary information material. AC: Ranges for soil properties in Enset gardens are rare in literature, especially with regard to differences between altitudes. Hence, we would like to keep the table in the main body of the text. Manuscript changes: we will use ns to denote non-significant results, to make the table easier to read.

RC2: L. 239-240. "The differences in soil..." This sentence can be removed. AC/manuscript changes: adapted as suggested.

RC2: L. 254-266. All this info is in Table 3, and this paragraph can be shortened by highlighting only relevant results. AC/manuscript changes: adapted as suggested.

RC2: L. 359-365. Any discussion on soil fertility without on-site data on crop yields remains highly speculative. AC: Kindly refer to our response to the general comment on the same issue.

RC2: L. 368-374. This discussion is largely based on nutrient contents previously reported for banana, which are not necessarily comparable to enset. This is explicitly recognized by the authors in L: 377-379, "optimal enset nutrient levels may differ substantially from those reported for banana." AC: Indeed, more information specific for Enset would be ideal. We however only found only two relevant references dealing with leaf nutrient content in enset (Uloro and Mengel (1994) and Nurfeta et al. (2008)), so we also added reference values for banana, which is of the same family and obviously much better studied. As the reviewer states, we explicitly stated in the text that this comparison should be made with caution. Manuscript changes: we will mention more clearly in table 8 which values are from studies done on enset, and which ones are for banana.

Please also note the supplement to this comment:
https://www.soil-discuss.net/soil-2019-78/soil-2019-78-AC2-supplement.pdf

Interactive comment on SOIL Discuss., https://doi.org/10.5194/soil-2019-78, 2019.