Prospects and limitations of farmers' knowledge and portable sensor equipment in soil salinity assessment and monitoring: A case study from Mozambique.

Tropentag 2023
September 20-22
Berlin

Jakob Herrmann[1], Júlio Lucas Muiumbo[2], Alberto Luis[3], Sebastião Famba[4], Matias Siueia Júnior[5]

[1]Weltweit - Association for the Promotion of Local Initiatives e.V., Bad Soden, Germany; [2]University Eduardo Mondlane, Faculty of Arts and Social Sciences - Geography Department, Maputo, Mozambique; [3]ABIODES - Association for Sustainable Development, Maputo, Mozambique; [4]University Eduardo Mondlane, Faculty of Agronomy and Forestry Engineering, Maputo, Mozambique; [5]Municipal Council Maputo, Department for Agriculture and Extension, Maputo, Mozambique.

Introduction

- Salinization of agricultural soil resources is an ever-increasing problem for global sustainable food production.
- Smallholder farmers and extension services in affected regions often lack the means to conduct comprehensive and timely salinity assessment.
- In these contexts, local knowledge systems on soil and water quality parameters prevail.
- Portable soil and water probes provide an increasingly accessible complementary tool [1].
- In order to evaluate the accuracy and validity of these alternative approaches, we conducted participatory mapping activities together with farmers of Maputo's vegetable production areas, in southern Mozambique.

Figure 1: Participatory mapping workshop (a), in-field data collection with portable sensor equipment STEP Systems COMBI 5000: Activity and pH reading in soil (b) EC and pH reading in water (c).

Methodology

- Participatory mapping workshops were conducted in 2018 and 2022 in two different locations of the study area, in order to define the perceived spatial dimensions of salinity. Satellite imagery print-outs served as working basis (Fig. 1a).
- Soil and water sampling followed each mapping exercise, for comparing farmers' categorization with standard salinity parameters (EC_e, EC_w). Respective analysis was conducted at the soil laboratory of the University Eduardo Mondlane, following standard procedures. EC_e values were calculated from $EC_{1:2.5}$ using locally established conversion factors [2]. Texture classes were determined by hand test.
- Since 2020, portable soil and water sensor equipment has been piloted by the SaliHort project in the study area. The 2022 data collection was therefore complemented by in-field readings of pH, EC and Activity (STEP Systems COMBI 5000, Fig. 1b+c).
- Local farmers' salinity zonation was compared with laboratory data via ANOVA and Fisher's LSD test. Probe-based readings were compared with laboratory data via correlation analysis. Where applicable, linear regression equations were established [3]. All statistical analysis was conducted in the R studio environment.

Results and Discussion 1

Local Salinity Assessment

- Farmers rely on a variety of indicators for salinity assessments: plant symptoms, salt crusts, tasting, indicator plants, crop yield.
- Local farmers' salinity zonation compared well with soil and water measurements in 2018. ANOVA and Fisher's LSD test confirmed farmer categories a+b, c, d and e as statistically distinctive entities based on either EC_e or EC_w measurements. In 2022, the same salinity categories were defined and delineated by the participating farmers for a neighboring location. However, they couldn't be substantiated by soil and water measurements (Fig. 2).
- We attributed this discrepancy to the occurrence of other constraining soil characteristics, mis-interpreted by farmers as salinity (e.g. low soil fertility, waterlogging, etc.), along with small-scale variability in salinity levels which partly contradict general trends. Another possible explanation could be stark seasonal fluctuations in salinity levels of upper soil layers which couldn't be captured by our data collection.

Figure 2: Measured salinity levels of upper 20 cm soil layer (EC_e) and irrigation water source (EC_w) plotted against local farmers' salinity categorization (a-e), for mapping exercises of 2018 (farmers' associations Thomas Sankara and Costa do Sol, n=40; upper section) and 2022 (farmers' associations Djaulane and Massacre de Mbuzine, n=97; lower section). Farmer salinity categories are defined as: (a) 'non-saline', (b) 'slightly saline' (25-50% yield loss), (c) 'saline' (50-75% yield loss), (d) 'too saline for crop production' (75-100% yield loss), (e) 'highly saline'.

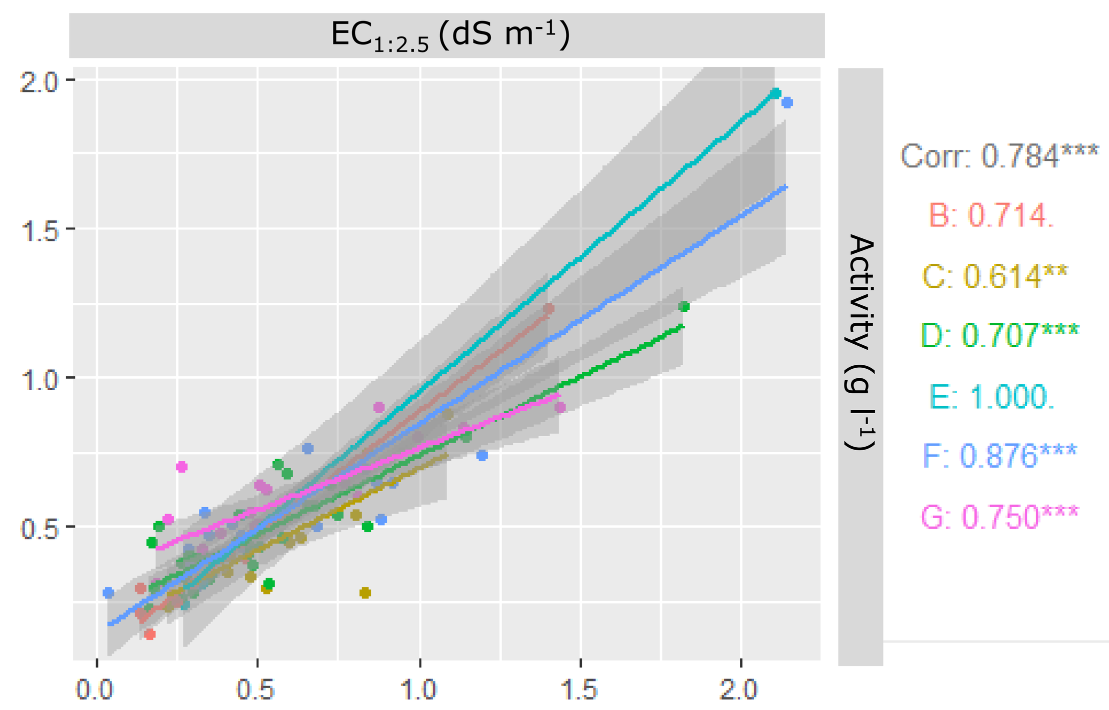
Conclusions and Outlook

- Local farmers' evaluation may serve as a tentative proxy indicator for salinity assessment.
- Farmers' salinity evaluation should be always complemented by either probe- or laboratory-based evaluations for cross checking and higher accuracy.
- Portable sensor equipment can be a valuable tool to improve salinity assessment. However, the development of robust locally adapted data collection procedures and conversion factors to standard parameters (EC_e) are required.

Results and Discussion 2

Probe-based Salinity Assessment

- Amongst the probe-based soil salinity readings, Activity correlated strongest with $EC_{1:2.5}$ as determined in the laboratory (r=0.784, n=107, p=3.91e^{-24}, Fig. 3).
- Respective linear regression equations were established, which didn't differ considerably between soil texture classes (Fig. 3).
- In-field Activity readings can therefore provide a quick and sufficiently accurate salinity evaluation.
- However, we suggest to extend the local data set in order to validate the proposed conversion factors. Furthermore, a direct relation between Activity and EC_e would increase accuracy.
- Probe measurements of pH and EC in water don't require conversion. They thus provide a straightforward complementary tool for salinity assessment in the field.



	Soil Texture	n	Equation (without intercept)	R^2
A	sand	0	-	-
B	sandy loam	8	$EC_{1:2.5}$ = 1.083 Activity	0.979
C	light loam	18	$EC_{1:2.5}$ = 1.199 Activity	0.933
D	loam	37	$EC_{1:2.5}$ = 1.094 Activity	0.917
E	clay loam	4	$EC_{1:2.5}$ = 1.064 Activity	0.997
F	light clay	20	$EC_{1:2.5}$ = 1.111 Activity	0.947
G	clay	20	$EC_{1:2.5}$ = 1.046 Activity	0.911
	combined	107	$EC_{1:2.5}$ = 1.096 Activity	0.936

Figure 3: Spearman correlation results for in-field Activity readings and $EC_{1:2.5}$ as determined in the laboratory (upper section), along with linear regression models relating Activity and $EC_{1:2.5}$. (lower section). Results are respectively shown for the whole data set and separated by soil texture classes (A-G).

References

[1] Stirzaker R, Mbakwe I, Mzirayas N R (2017) A soil water and solute learning system for small-scale irrigators in Africa. International Journal of Water Resources Development 33:5, pp 788-803.

[2] Serno G, Neto V (1989) Estudo das Relações entre $CE_{1:2.5}$ e CE_e para Diferentes Grupos de Textura do Solo. Série Terra e Água. Instituto de Investigação Agrária de Moçambique (IIAM), Maputo.

[3] Shahid S A, Zaman M, Heng L (2018) Introduction to Soil Salinity, Sodicity and Diagnostics Techniques. In: Guideline for Salinity Assessment, Mitigation and Adaptation Using Nuclear and Related Techniques, pp 1-42. Springer Cham.

Acknowledgements

This work was principally realized in the context of the project SaliHort (Piloting Strategies to Mitigate Impacts of Salinity in Horticultural Systems of Mozambique), funded by The Conservation, Food & Health Foundation, Development Cooperation of the German Federal State of Hesse, Stiftung Ursula Merz, and Hand-in-Hand-Fonds (https://welt-weit.org). Prior research phases were funded by Stiftung für Tropische Agrarforschung (Berlin) and supported by the project UFiSAMo (https://www.sle-berlin.de/index.php/en/research/completed-research-projects/ufisamo).

ABIODES ASSOCIAÇÃO PARA DESENVOLVIMENTO SUSTENTÁVEL

MUNICÍPIO DE MAPUTO Povo Unido e Soberano

UNIVERSIDADE EDUARDO MONDLANE