Regional investigation of spatial-temporal variability of soil potassium, a study case in Switzerland

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Objectives

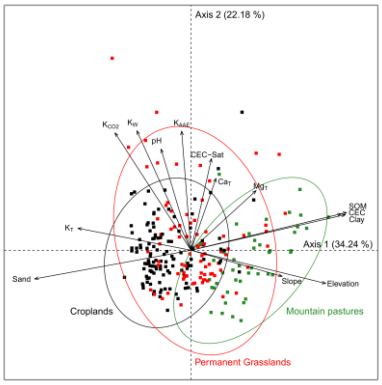
The objectives of this study were to

(i) characterize the soil K status in the Fribourg canton according to four different extraction methods;
(ii) analyse the spatial & temporal variability of soil K in relation to land use, soil type, soil parent material and topography;
(iii) evaluate the spatial predictability of K at the canton level;
(iv) analyse the implications for K fertilization management.

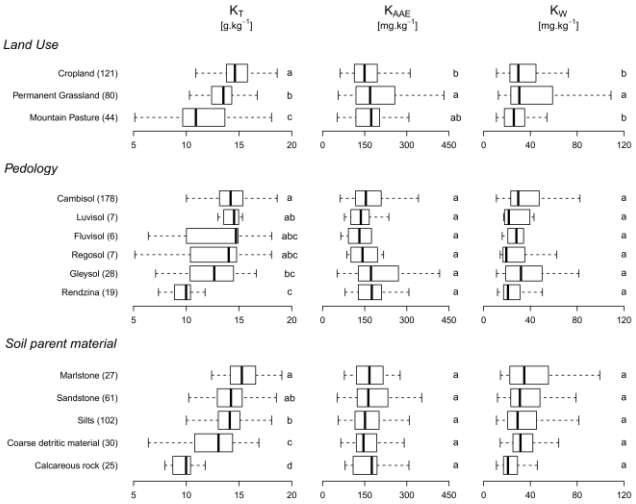
Material and methods

- The FRIBO network established in 1987 includes 250 sampling sites distributed along an approximate 2*2 km grid covering croplands, permanent grassland and mountain pastures;
- Soil samples were analyzed for total K (K_T) and available K (K_W: water extraction, K_{AAE}: ammonium acetate EDTA extraction);
- Spatial variability of K forms was based on regression kriging using environmental predictors derived from Digital Elevation Model (DEM), soil types, parent material and land use;
- A one-way analysis of variance (ANOVA) was conducted to compare the differences in total K between 1st and 5th cycle.

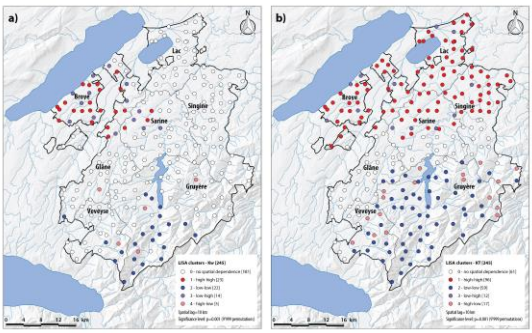
Results



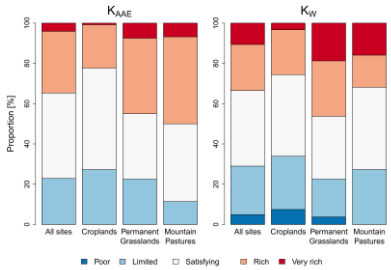
Principal component analysis of main soil and environmental variables and K forms (n=245).



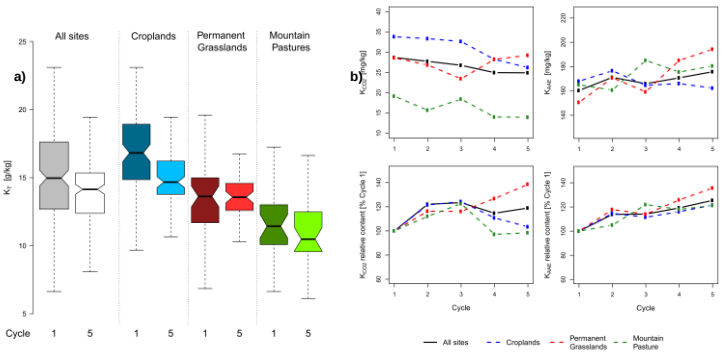
Boxplots of the different K pools of the upper soil layer (0-20 cm) in the FRIBO network (245 sites) according to land use, pedology and soil parent material. Soil types were classified according to the FAO classification. Soil parent materials were extracted from geological maps (Geological Vector Datasets 1:25000 of Swisstopo) and aggregated into 5 simplified groups. Numbers under brackets refer to the number of sites of the given category. Letters correspond to Tukey's groups: different letters indicate significant differences at $p < 0.05$.



Cluster map of the Local Indices of Spatial Association (LISA) for K_T (a) and K_W (b) with a spatial lag of 10km. Results are significant at p=0.001 (9'999 permutations). The five distinct classes are: (i) in red: high K values correlated with high weighted K values; (ii) in blue: low K values correlated with low weighted K values; (iii) in violet: a low-high relationship between K and weighted K, (iv) in pink: a high–low relationship between K and weighted K, and finally (v) white circles show places where there is no significant spatial dependence. The background shows the digital elevation model. The lower the altitude, the darker the color.



Distribution of the soil K fertility categories for all sites and each land use according to the Swiss fertilization guidelines (Sinaj et al., 2009).



Temporal trends of soil K forms. a) Boxplots for cycles 1 and 5 of soil total K. b) Average temporal curves for available K forms. Upper graph refers to mean absolute values and lower graph refers to mean relative values (relatively to cycle 1).

Conclusions

- The spatial distribution showed areas of high K_T and available K (K_W and K_{AAE}) forms mostly around Neuchatel Lake, due in part to land uses with croplands displaying the highest values for all K forms.
- The spatial predictions for the available K forms had relatively sharper boundaries compared to K_T perhaps due to different land uses and management practices within the land use particularly agricultural land.
- The K_T decreased between the 1st (1987) and 5th (2010) cycle for all sites combined. However, croplands had the largest decreases from 17 to 14.5 g kg^{-1}, while the temporal trends for available K form were less clear.
- Despite a recent analysis on national scale that suggests current surplus of K in soil due to farming activities, the results from our long term study indicate the need for a closer look at the overall soil K status. Maintaining a positive balance of K is important for the long term soil suitability.

References

- Blanchet et al. 2017. Geoderma 290, 107-121.

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