

Improving smallholder soil fertility and production through ISFM utilization in South Kivu, DR Congo

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Introduction

- Crop productivity in many smallholder farms in South Kivu is chronically low
- The overriding cause to failing yields lies in limited availability of nutrients due to soil and management factors
- In smallholder agriculture in South Kivu use of chemical fertilizer is absent
- One fertilizer recommendation can't be applied to the whole wide region where strong variability in crop yield and soil responsiveness is observed

Study area



Fig. 1 Sentinel sites in South Kivu, DR Congo

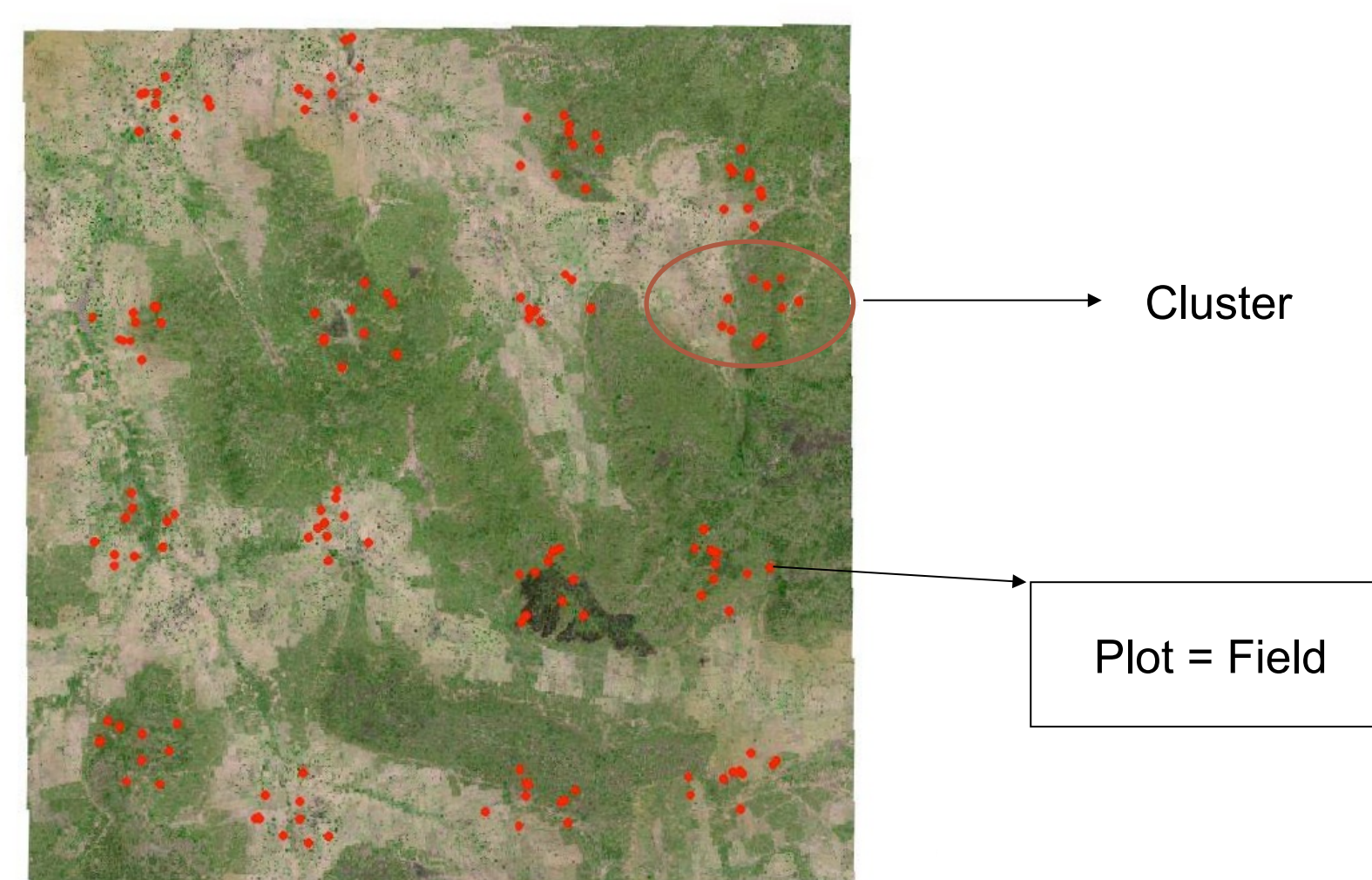


Fig. 2 One sentinel site with clusters and plots

4 sentinel sites:

- 2 characterized: Burhale (South on map) and Luhihi (North on map)
- 2 non-characterized: Lurhala (South) and Kabamba (North)

A sentinel is divided into 16 equal clusters in which 10 plots are randomly selected

Variation of nutrient content in soils

Objective: to assess the variability of soil nutrient content and fertilizer use within two characterized sentinel sites (Burhale and Luhihi)

Methods:

534 composite soil samples were taken from two different depths (0-20 and 20-40 cm) in cultivated and uncultivated land using a stratified random sampling design. Differences were evaluated between sentinels, clusters, land use and soil depth

Results:

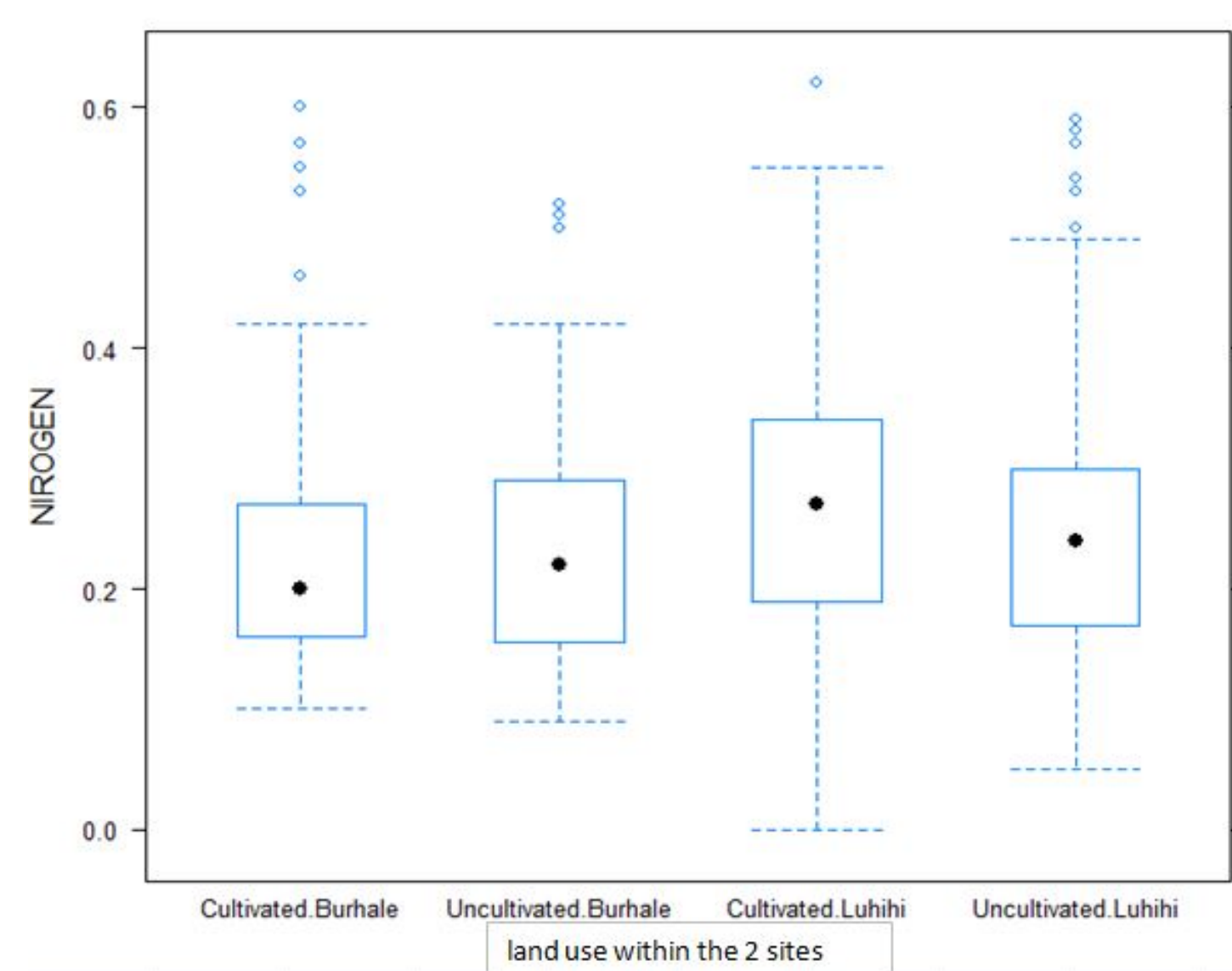


Fig. 3 Variation in nitrogen content (%) for Burhale and Luhihi

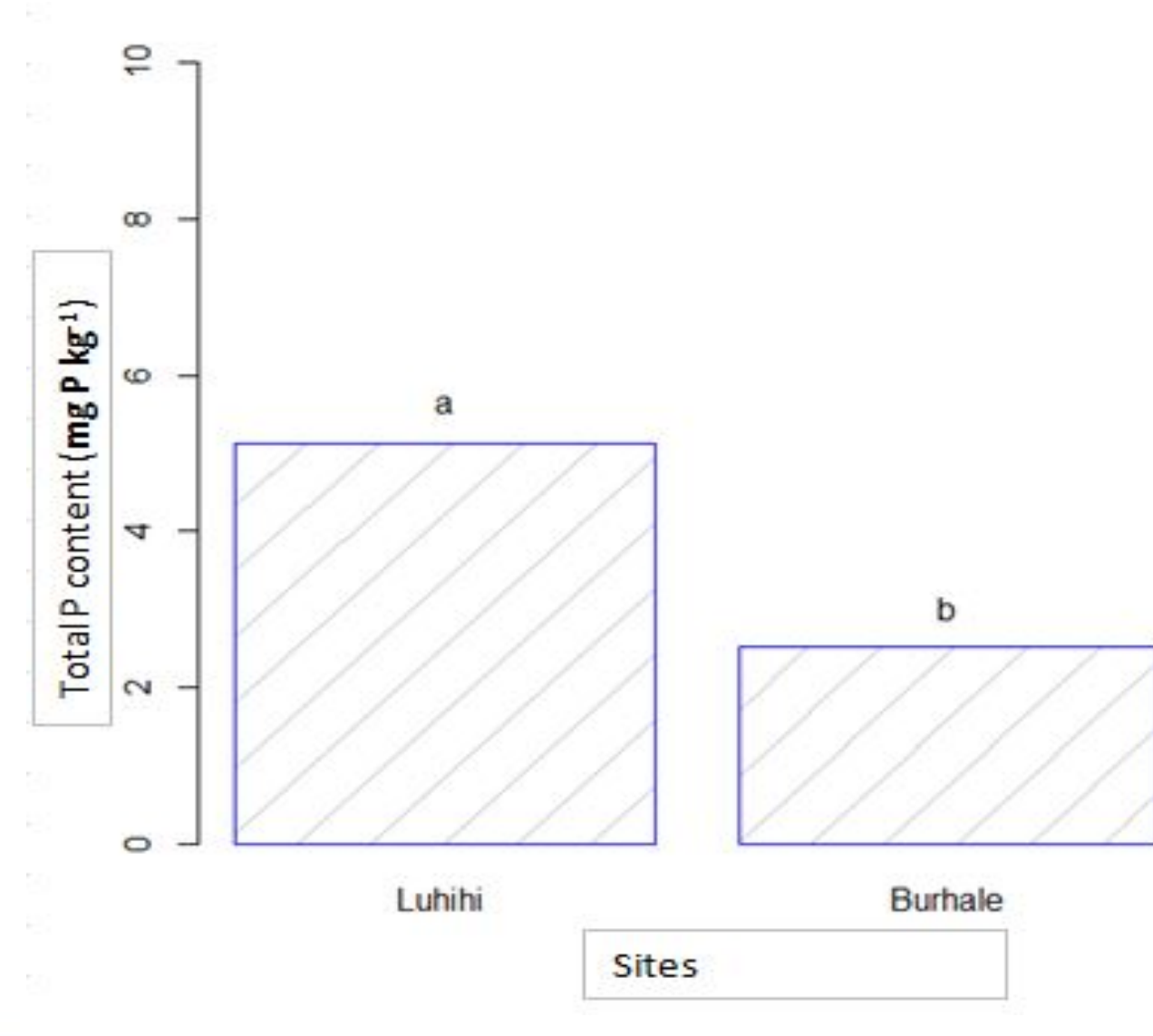


Fig. 4 Total phosphorus (mg P kg⁻¹) content in Luhihi and Burhale

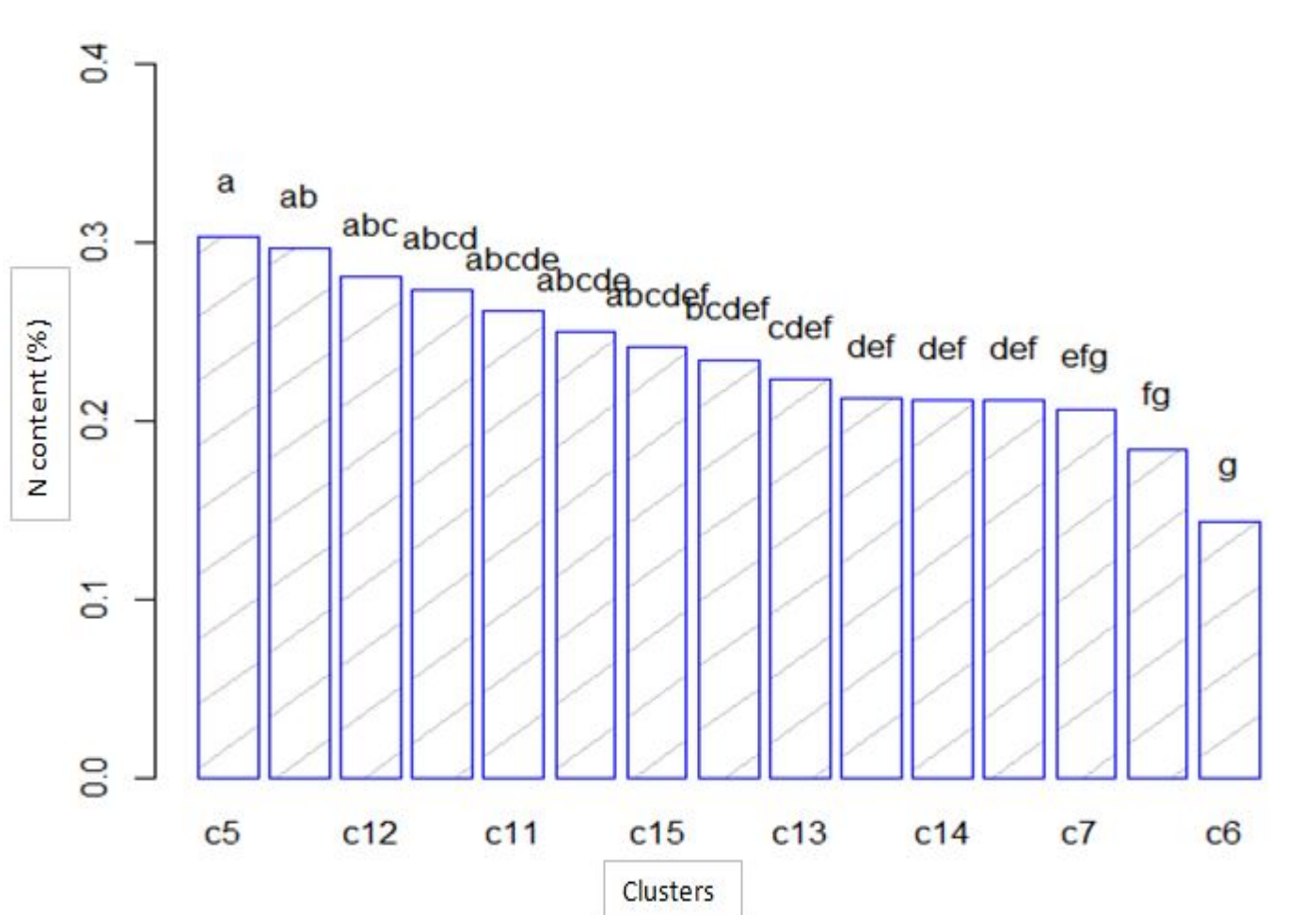


Fig. 5 Nitrogen content (%) variation within Burhale clusters



- No difference in K content in both sentinels, but variation was present within clusters and depth
- The studied area is acidic (top soil pH is 4.6 ± 0.34) (not shown)
- In both sentinels Ca ($<4 \pm 1.2$ cmolc kg⁻¹) and Mg ($<2 \pm 0.8$ cmolc kg⁻¹) is low;
- Soil organic carbon content is higher for cultivated plots in Luhihi ($3.9 \pm 1.6\%$) than in Burhale ($3.0 \pm 1.4\%$)
- Phosphorus deficiency is acute for Burhale (2.4 ± 3.2 mg P kg⁻¹) but less for Luhihi (5.4 mg \pm 4.2 P kg⁻¹) (Fig. 4)
- Nitrogen and phosphorus content show variation between sites, cluster, soil depth and land use (Fig. 3, 4 & 5)

Understanding major determinants of fertilizer use

Objective: identify socio-economic constraints that determine both organic and inorganic fertilizer use by smallholder farmers

Methods:

A survey on determinants of fertilizer use was administered to ca. 400 farmers who were randomly selected from villages within the study area

Results:

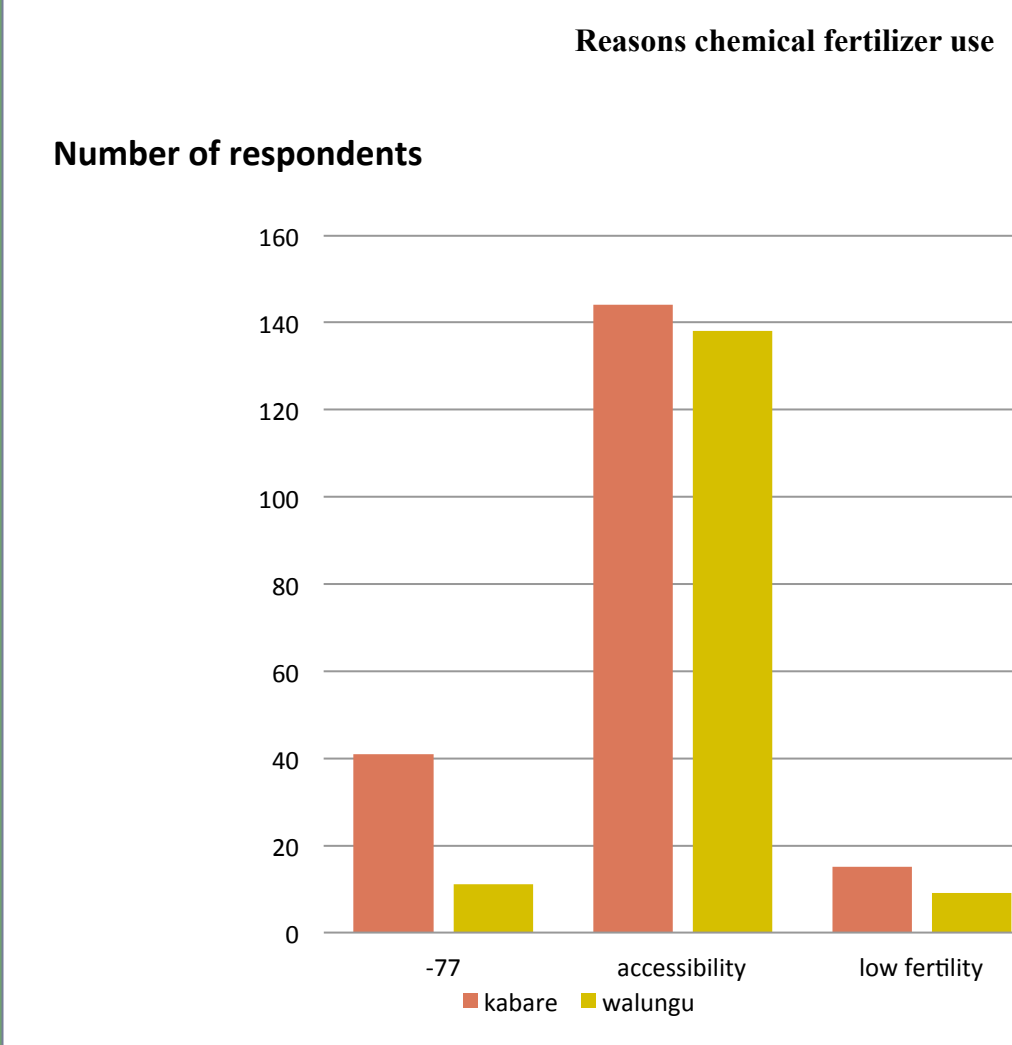


Fig. 6 Chemical and organic fertilizer use in Kabare and Walungu in South Kivu, DR Congo

Table 1. Determinants for organic fertilizer use (P<0.05)

determinant	Estimate	Standard Error	Z value	Pr(> Z)
Intercept	1.102 e+01	4.986 e+03	0.002	0.99824
household people working fulltime in the farm (number)	-1.285 e-01	3.156 e+02	-4.070	4.7 e-05***
livestock ownship (yes,no)	1.259 e+00	5.512 e+01	2.284	0.02235*
Land ownership (inheritance, purchase, otherwise)	2.571 e 00	1.098 e+00	-2.341	0.01922*
fertility status, farmers evaluation (high, medium, low)	2.980 e 00	1.079 e+00	2.761	0.00576**
Own stock	5.4143	1.0216	5.300	1.16 e-07***

Table 2. Determinants for chemical fertilizer use (P<0.05)

determinant	Estimate	Standard Error	Z value	Pr(> Z)
Intercept	-6.319e+00	3.219e+00	-1.963	0.049627 *
household leader age > 50 ans	-1.754e+01	3.279e+03	-0.005	0.995731
fertilizers access	7.727e+00	2.149e+00	3.596	0.000324 ***
years of formal education of farmers (degree)	-3.6136	0.9283	-3.893	9.91e-05 ***

- Organic fertilizers are more used (91%) than chemical fertilizer (0.02%) (not shown);
- Logit model (Table 1 and 2) revealed that fertilizer use has (at household level):
 - **Positive effect:**
 - Land and livestock ownership, poor soil type, higher level of education (organic fertilizer);
 - Access to fertilizer (chemical fertilizer)
 - **Negative effect:**
 - Gender, household size, non involvement in rural development organizations, small size of farms, lack of extension and credit programs regarding fertilizers (organic);
 - Age (>50 yr.), low level of education, non involvement in rural development organizations, fertilizers price and lack of extension and credit for chemical fertilizers

Soil nutrient constraints in smallholder farms

Objective: Determination of limiting soil nutrients to crop growth and yield

Methods:

Productivity of maize was evaluated under omission of either nitrogen (N), phosphorus (P) or potassium (K) to identify their particular deficiency to crop growth and yield. A FYM+NPK treatment was included to assess constraints related to acidity and soil OM content

Trials were carried out in 4 sites: Burhale, Lurhala, Kabamba and Luhihi (Fig. 1)

Results:

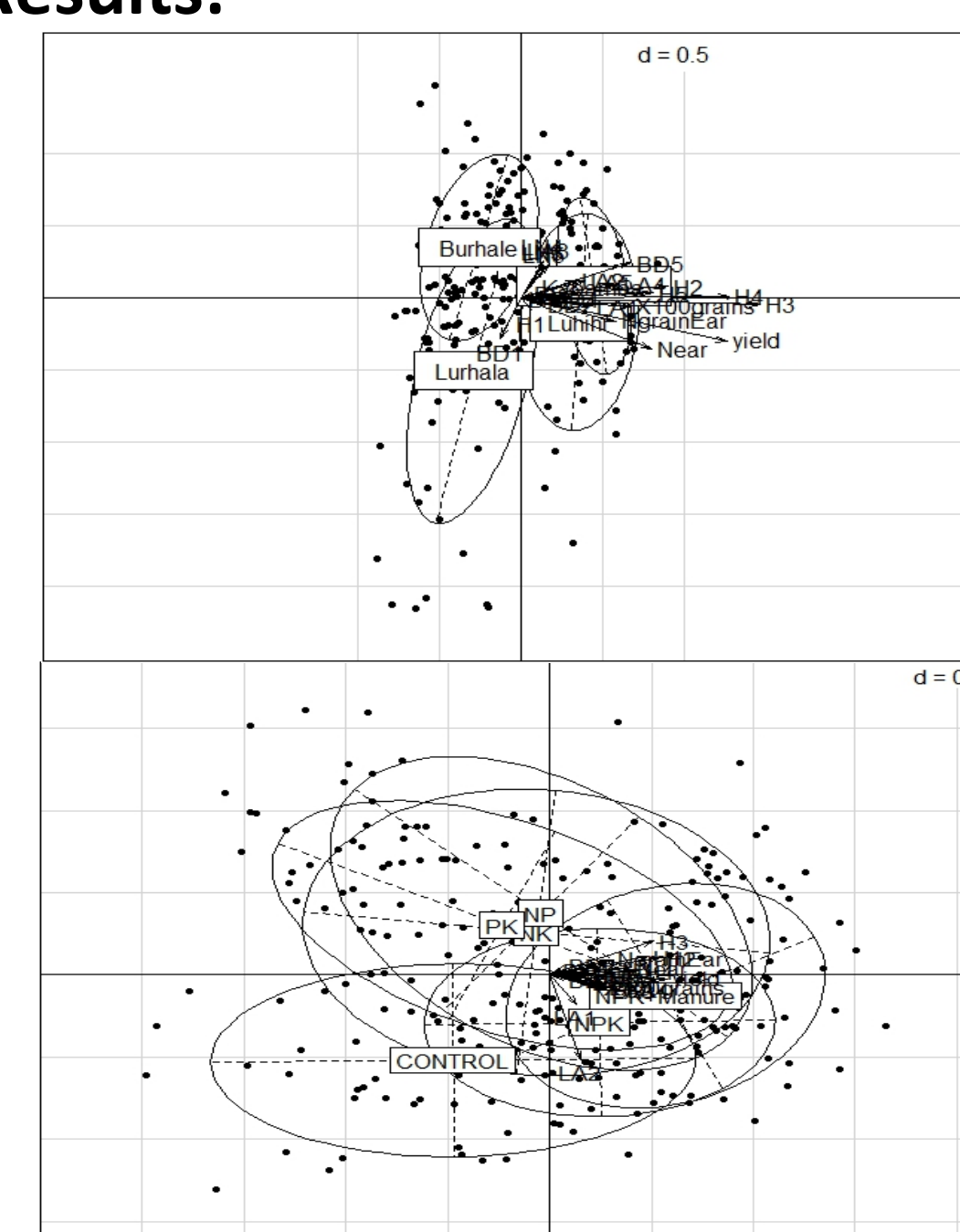


Fig. 8 PCoA on maize agronomic data as determined by sites and fertilizers (vectors indicate strength and direction of the correlation between functional parameters)

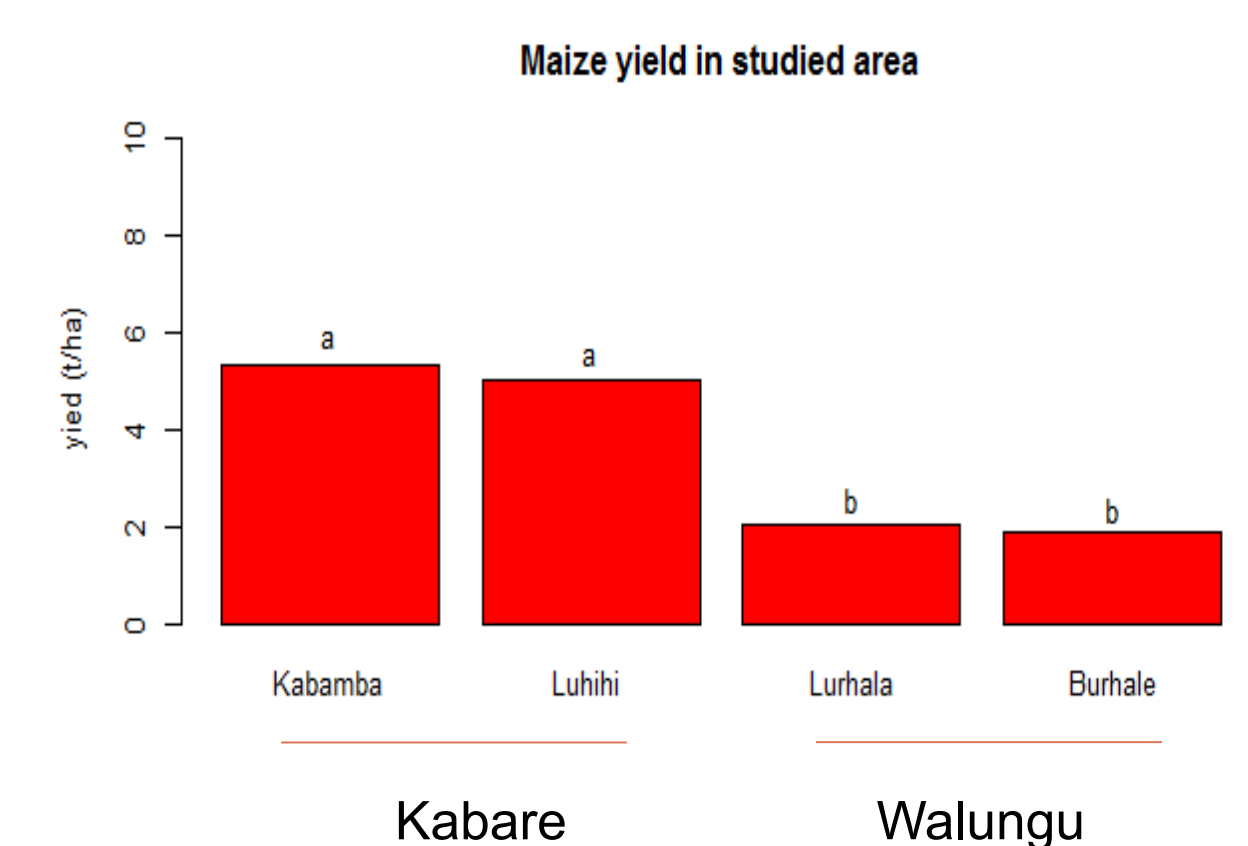


Fig. 7 Maize yield (t ha⁻¹) as affected by fertilizer type, sentinel and region

- Key productivity parameters (plant height and yield) were consistently lower in Burhale and Lurhala (Walungu region) than in Kabamba and Luhihi (Kabare region)
- Strong geographical dependency of soil fertility:
 - In the Walungu locations all fertilized treatments were significantly higher than the non-fertilized control treatment, irrespective of nutrient omissions
 - In the Kabare locations, in turn, only full NPK application combined with manure was significantly higher from the control
- From the studied area:
 - Productivity of maize decreased when N and P were not applied, in these cases the availability of N showed to be more limiting than P
 - FYM application increased maize productivity (+effect on soil pH and OM content)

Conclusion

- Most nutrient contents are lower in Burhale than Luhihi and showed strong variation between top- and sub-soil, cluster and land use
- N is the most limiting nutrient, followed by P (specifically for Walungu) and in some locations K
- Increased adoption of inorganic fertilizer combined with FYM use will be pursued as a strategy to revitalize smallholder's agricultural sector in South Kivu

Acknowledgement

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