Soil fertility status in relation to farmers' practices under maize based systems in Western Region of Kenya: yield gap analysis

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Abstract

A study was carried out in Kenya Cereal Enhancement Project site in Western region of Kenya to examine the soil fertility status in relation to the current blanket fertilizer recommendations and farmers' practices across the four wards, namely: Motosiet, Keiyo, Cherangani and Kwanza. The baseline fertility status in different soil mapping units was assessed in terms of soil productivity index with a view of analyzing the levels of nutrients and yield gaps. Using the standard soil survey procedures, six soil mapping units were identified as UUr1, UUr2, UUr3, RUd, RUrb, and BU1.. The results showed that the highest productivity index was in unit BU1, followed by UUr1, UUr2, UUr3, and RUrb with values of 40.5, 29.4, 25.0, 16.0 and 8.9% respectively. Keiyo Ward had the highest level of nitrogen, being 125.82, followed by Motosiet, Cherangani and Kwanza with values of 99.92, 97.12, and 81.12 kg/ha respectively. Phosphorous level was highest in Kwanza (136.41 kg/ha), followed by Cherangani (106.82 kg/ha) and Keiyo Ward (76.08 kg/ha). The lowest level was recorded in Motosiet with the value of 72.56 kg/ha. Potassium was found to be adequate in all the four Wards with values ranging between 347.67 and 410.34 kg/ha. The maximum maize production recorded in the project sites was 9,000 kg/ha, with a yield gap of 1,000 kg/ha. This was achieved through application of 100 and 50 kg/ha of DAP and CAN respectively. This was followed by 6,750 kg/ha obtained through application of 50 kg/ha of DAP and CAN. The yields from the rest of the sites ranged between 1,800 and 4,500 kg/ha with yield gaps varying from 3,250 to 8,650 kg/ha. The lowest yields were obtained in Keiyo, followed by Kwanza Ward despite the relatively high macro-nutrient levels in the soils of the two Wards. This was attributed to soil-related constraints caused by the increased soil structural degradation and loss of soil tilth . Therefore, it is recommended that the envisaged climate smart technologies be geared towards enhancement of nutrient and water use efficiency through improved soil structure and tilth.

Key words: Productivity index, soil-related constraints and yield gaps

1 Introduction

1.1 The study background

Most fertilizer recommendations in Kenya were formulated many years ago, disregarding the effects of variations in soil properties and climate change. As a result, several recommendations have become obsolete. Assessment of soil fertility and potential for a specified land use system attempts to answer the question on how the land is currently used and managed as well as the impact of the farmers' practices on soil fertility and crop yield. Addressing such question is an important component of the biophysical characterization and fertility mapping carried out for Kenya Cereal Enhancement Programme (KCEP) in Western region of Kenya (Kamoni et al. (2016).

To graduate farmers from subsistence farming and food insecurity to market-oriented farming, KCEP is addressing the key soil-related constraints to crop production by promoting good agricultural practices. Identification of good agricultural practices necessitates the establishment of the baseline soil fertility status to be used as a basis of evaluating the impacts of the change from the current practices to envisaged interventions on soil productivity. According to Driessen and Konijn (1992), assessment of baseline soil productivity usually involves integrated analysis of biophysical and socio-economic data collected through land use system analysis. In its simplest form, a land use system is composed of one land utilization type practised on one land unit. The sufficiency of the land unit properties is determined by measuring and matching the values of the selected land and soil quality indicators with the values for optimum production of the specific land use on the defined land unit. In assessing the potentials and limitations of land for a given land use system, distinction is made between land quality and soil quality. Land quality is defined as the condition, state or health of the land in relation to crop requirement, while soil quality is the capacity of a specific soil type to function within natural or managed ecosystem boundaries to sustain plant and animal production, maintain or enhance water quality, and support human health and habitation (Doran and Parkin, 1994). Although soil survey and fertility mapping are based on the soil natural boundaries, ecosystem boundaries are also considered when the impacts of land use becomes significant in reducing, sustaining, or enhancing water quality and availability through changes in soil depth. Driessen and Konijn (1992) showed that soil depth was one of the single land characteristics that was so positively correlated to crop production that separation of the same soils into different units, based on soil depth would show different levels of biophysical soil potentials and ecosystem functions.

1.2 Soil biophysical potential and its management implications

The biophysical production potential of any production system is realized when nutrient supply, plant protection and harvesting methods are optimized and the crop yield is limited only by sunshine, temperature and water. It is a fully optimized production situation, and is normally much greater than the production realized under ordinary farming circumstances. The yield gap between the biophysical production potential and the observed actual production from the farmers' fields results from the compounded effects of all the limitations that confront the real world farmer, that are supposed to be corrected by the envisaged intervention strategies (Driessen, 1997). If all the correctable limitations are eliminated, a system's biophysical performance would only be limited by the amount incoming solar energy, temperature and photosynthetic properties of the crop concerned. In glasshouses, even light and temperature can be optimized and production becomes limited only by the properties of the crop, since water supply can also be optimized. This explains why in Dutch glasshouses, tomato production reaches an incredible 500 tons/ha/year. In this context, an assessment of soil, environmental conditions, farmers' practices and crop yields prior to the identification of the appropriate intervention strategies, is a noble task, because the yield gap established for the specific land use system is an indicator of the magnitude of the management inputs required through the prescribed intervention, following the experimental research. In this case, the use of external inputs, principally fertilizers and lime, together with the use of improved crop varieties may sustain high crop yields if they are sufficiently tailored to specific land use system with known soil-related constraints and management requirements (Muya et al., 2015). Against this background, the objectives of the study were:

1. To examine the current blanket fertilizer recommendations across major soil types in different wards, the expected crop yields, farmers’ practices and yield gaps.
2. To assess the baseline fertility status in terms of soil productivity.
3. To analyze levels of nutrients in the soils in the identified soil mapping units as a basis of recommending appropriate fertilizer blends.
4. To analyze the relevance of the envisaged technologies to the identified soil-related constraints and predict their impacts on agricultural productivity

2 Materials and methods

2.1 The study area

2.1.1 Location

The study area lies within the four Wards of Trans Nzoia County, between latitudes 34^{o} 30” E and 35^{o} 30” E and longitudes 1^{o} 30”N and 1^{o} 45”N. Fourty four farmers’ fields were selected, each measuring 0.4ha, being distributed within the four Wards, namely: Motosiet, Cherangany, Kwanza and Keiyo.

2.1.2 Climatic aspects of the area, effective rains and consumptive water use

The most important climatic characteristics presented are temperatures and rainfall due to their direct influence on plant growth. The optimum temperature range for most crops is 10 to 30^{o}C, which falls within the range of the values obtained from the study sites (Table 1). Another important aspect of climate which is of the interest for study is effective rainfall. The effective rain is the fraction of rain water that infiltrates into the soil and stored within the rootzone to be consumed by the plants. It is a reflection of the interactions between climate, soil, topographical characteristics and management (e.g. tillage and terraces). The project area, being highly compact, is bound to generate relatively high volume run-off, hence low effective rain. Therefore, water deficits occur mainly between January and April when water losses through run-off are at its peak level. The negative run-off, occurring in November, is an indication of accumulation of water from other ecosystems, which needs to be intercepted through construction of appropriate tillage or other water conservation structures. Increased rates of run-off due to high soil compaction and the attendant loss of nutrient bases is one of the explanations of the increasing soil acidity and nutrient deficiency in the area. Therefore, this is one of the key soil physical and fertility constraints requiring improvement (Muya *et al.*, 2015).