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Cassava yield loss in farmer fields was mainly caused by low soil fertility and suboptimal management practices in two provinces of the Democratic Republic of Congo

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ABSTRACT

A better understanding of the factors that contribute to low cassava yields in farmers' fields is required to guide the formulation of cassava intensification programs. Using a boundary line approach, we analysed the contribution of soil fertility, pest and disease infestation and farmers' cultivation practices to the cassava yield gap in Kongo Central (KC) and Tshopo (TSH) provinces of the Democratic Republic of Congo. Data were obtained by monitoring 42 and 37 farmer-managed cassava fields during two cropping cycles in KC and one cropping cycle in TSH, respectively. Each field was visited three times over the cassava growing period for the observations. Logistic model was fitted against the observed maximum cassava root yields and used to calculate the achievable yield per field and for individual factor. At field level, the factor that led to the lowest achievable yield ($Y_{up(i)1}$) was considered as the dominant yield constraint. Cassava yield loss per field was expressed as the increase in the maximal root yield observed per province (Y_{att}- attainable yield) compared to $Y_{up(i)1}$. Y_{att} was 21 and 24 t ha^{-1} in TSH and KC, respectively. With the cassava varieties that farmers are growing in the study areas, pests and diseases played a sparse role in the yield losses. Cassava mosaic was the only visible disease we observed and it was the dominant yield constraint in 3% and 12% of the fields in KC and TSH, respectively. The frequent yield constraints were suboptimal field management and low soil fertility. Cultivation practices and soil parameters led to $Y_{up(i)1}$ in 47% and 50% of the fields in KC, and in 47% and 41% of those in TSH, respectively. Individual soil parameters were the yield constraint in few fields, suggesting that large-scale programs in terms of lime application or recommendation of the blanket fertilisers would result in sparse efficacy. In KC, yield losses caused by low soil fertility averaged 6.2 t ha^{-1} and were higher than those caused by suboptimal field management (5.5 t ha^{-1}); almost nil for cassava mosaic disease (CMD). In TSH, yield losses caused by low soil fertility (4.5 t ha^{-1}) were lower than those caused by suboptimal field management (6.5 t ha^{-1}) and CMD (6.1 t ha^{-1}). Irrespective of the constraint type, yield loss per field was up to 48% and 64% of the Y_{att} in KC and TSH, respectively. Scenario analysis indicated that the yield losses would remain at about two third of these levels while the dominant constraint was only overcome. We concluded that integrated and site-specific management practices are needed to close the cassava yield gap and maximize the efficacy of cassava intensification programs.

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1. Introduction

Despite several efforts, mainly in terms of dissemination of improved genotypes and integrated pest and disease management, cassava productivity in African smallholder's farming systems is below the optimal level, although some increases in yields have been observed (Rusike et al., 2010; Zinga et al., 2013). Average cassava fresh root yield increased in Africa from 6 to 10 t ha^{-1} over the last 50 years but it is still much lower than the current average yields of 22 t ha^{-1} in Asia (FAOStat, 2015). In sub-Saharan Africa (SSA), cassava yields under research management fields are most often larger than those under smallholder farmer management fields. In East Africa for instance, Obiero (2004), Ntawuruhunga et al. (2006) and Legg et al. (2006) recorded cassava fresh root yields of 60 t ha^{-1} under experimental conditions, while Fermont et al. (2010) observed 6–17 t ha^{-1} of cassava fresh root yields in Kenyan and Ugandan farmer fields. In the Democratic Republic of Congo (DRC), the yields of cassava genotypes in research-managed systems are at least twice as those in farmer-managed systems (Unpublished data). In this context, reducing the gaps between cassava yields under research- and farmer-managed systems is a crucial concern in Africa, especially as cassava is moving from a subsistence crop to one of the major commercialized crops and appears to be one of the promising crops to mitigate drought resulting from climate change. To reduce the yield gap, a better understanding of the factors contributing to low cassava yields is needed, as this can help to design intensification programs and prioritize the interventions in the context of limited available resources. While there is agreement on low cassava productivity because of poor crop management (e.g., late weed control and cassava planting at low density) and pest and disease infestation (Albuquerque et al., 2014), opinions differ on the response of cassava to inherent soil fertility. Compared with many other crops, cassava is generally perceived as tolerant of low soil fertility (Howeler, 2002). Most farmers believe that cassava can restore the fertility of degraded soils and it does not need external nutrient inputs to soils (Leihner, 2002). This explains why many farmers grow cassava on marginal land or land that is about to be abandoned to natural regeneration (Hillocks, 2002; Saïdou et al., 2004; Adjei-Nsiah et al., 2007). In almost all cases where soil fertility was cited among the limiting factors of cassava productivity, the authors emphasized on soil exchangeable K as cassava removes more K than other crops (Howeler et al., 1987; Howeler et al., 1991; Carsky and Toukourou, 2005). Other soil fertility related constraints, such as imbalanced nutrient contents and high content of undesirable nutrients (e.g., zinc and aluminium) may also reduce cassava productivity (Cassman et al., 2002; Ezui et al., 2016).

Boundary line analysis has been used to assess the relative contribution of individual factors to yield gaps of cereals, banana, coffee

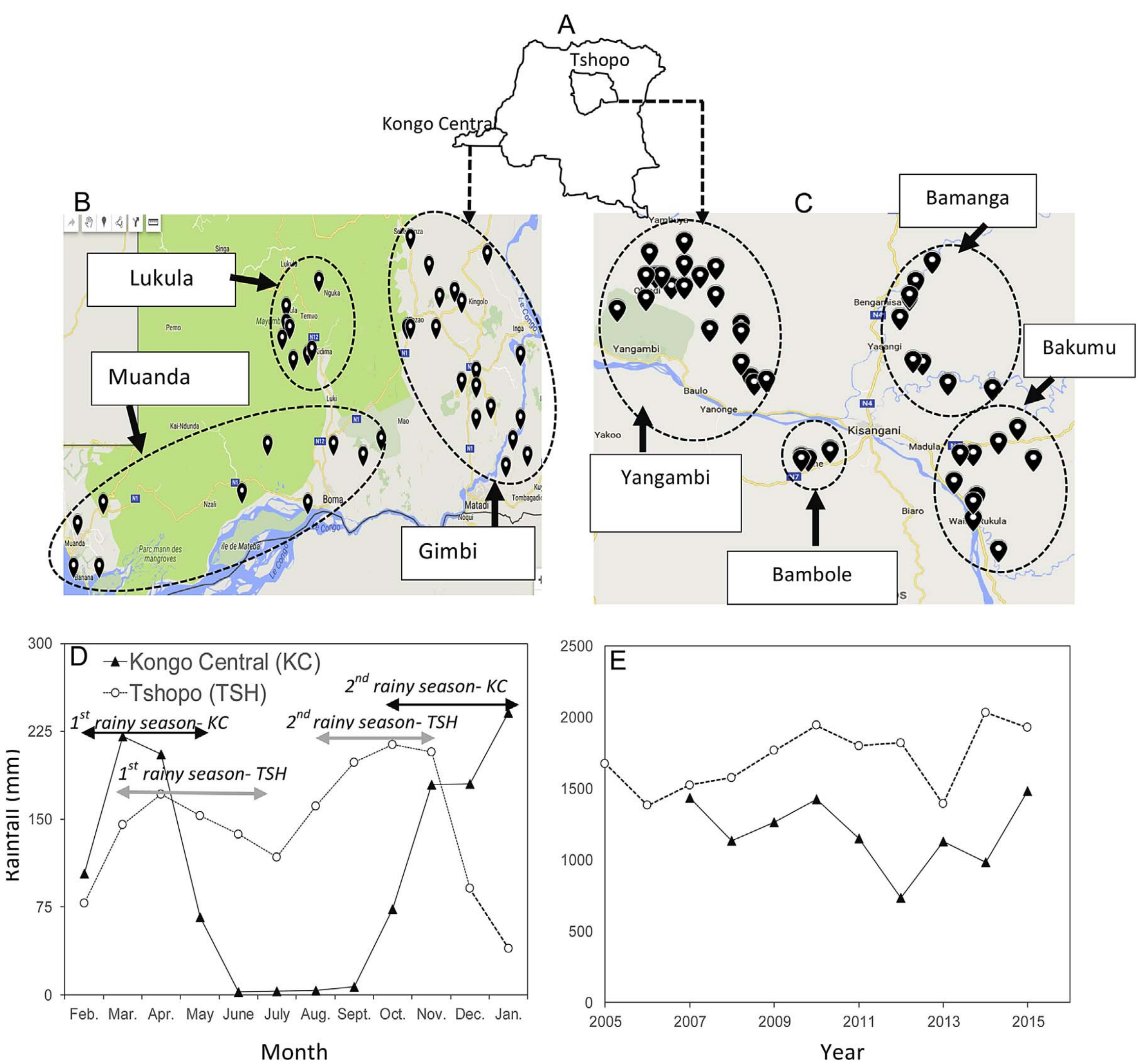

Fig. 1. Study provinces (A) and global positioning system (GPS) of the monitored farmer fields in Kongo Central (B) and Tshopo (C). Monthly (D) and annually (E) rainfalls in Central Kongo and Tshopo as respectively illustrated by data collected from 2007 to 2015 at Gimbi and average of those collected at Litoy and Yangambi from 2005 to 2015 of unexplained yield gaps.