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Wheat yield gaps in the Ethiopian highlands: Insights at farm(ing) system levels for better targeting development interventions

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Introduction

Ethiopia is the largest wheat producer in sub-Saharan Africa but it still depends on wheat imports to satisfy domestic demand. This puts pressure on foreign exchange reserves and increases the vulnerability of the national economy to shocks from global markets. Moreover, further increases in demand for wheat and other cereals are expected in the future due to population growth and dietary changes (van Ittersum et al., 2016). These drivers brought wheat self-sufficiency high on the agenda, with a new initiative of the Ethiopian government aiming to achieve it in the coming four years.

Narrowing wheat yield gaps in Ethiopia is important to reduce imports of this crop in the years ahead. Most likely this will have to occur in a smallholder setting, under rainfed conditions, where few external inputs are used and crop management relies heavily on human labour and draught power (e.g., Silva et al., 2019). Despite the yield progress observed in the past, a large yield gap remains (ca. 80% of the water-limited yield, Yw) meaning it is possible to increase actual yields further (www.yieldgap.org). The objective of this paper is to decompose wheat yield gaps into efficiency, resource and technology yield gaps across different regions in the Ethiopian highlands, and to help prioritizing policies towards achieving wheat self-sufficiency in the country.

Materials and methods

Wheat yield gaps were decomposed for a given climate zone and soil type following the framework of Silva et al. (2017). The efficiency yield gap was calculated as the difference between actual yields (Ya) and technical efficient yields (Y_{TEx}), estimated with stochastic frontier analysis. The resource yield gap was calculated as the difference between the Y_{TEx} and the highest farmers' yields (Y_{HF}), corresponding to the average top 10th percentile Ya. Finally, the technology yield gap was calculated as the difference between Y_{HF} and water-limited potential yields (Yw). Water-limited yields were simulated with the crop growth model WOFOST according to the protocols of the Global Yield Gap Atlas. Yield gaps were further aggregated to administrative zones and to farming systems as defined by Amede et al. (2017).

Actual farmers' yield data were retrieved from the Wheat Adoption and Impact Survey (WAIS) conducted by CIMMYT. The survey is a panel of households and includes detailed information on crop management and yields for different fields of each farm for the main rainy season (*Meher*) of 2011 and 2013. All data was obtained through farmer recall. The sample were selected according to a stratified sampling frame, comprising the selection of 148 major wheat growing districts of Ethiopia, followed by a random selection of farmers' associations within these districts and by a random selection of 15 to 18 households within each farmers' association. This resulted in a sample of representative farmers across the country ($n \approx 2000$).

Results

Wheat Ya in farmers' fields were between 0 – 8 t DM ha^{-1}, while simulated Yw ranged between 7.5 – 11.5 t DM ha^{-1} during the study period (Figure 1A). On average, Ya was greater in Arsi (2.2 t DM ha^{-1}, 20% Yw) than in the other regions, namely Gojam (1.5 t DM ha^{-1}, 20% Yw) and Wollo (1.2 t DM ha^{-1}, 13% Yw), but in all regions very low Ya were observed (average 1.7 t DM ha^{-1}). Yw was also greatest in Arsi (> 9 t DM ha^{-1}, Figure 1A), confirming the suitability of this region for wheat production. The yield gap closure was well below 60% for most fields (Figure 1B), with an average of ca. 20% Yw across administrative regions (Figure 1C) and farming systems (Figure 1D).

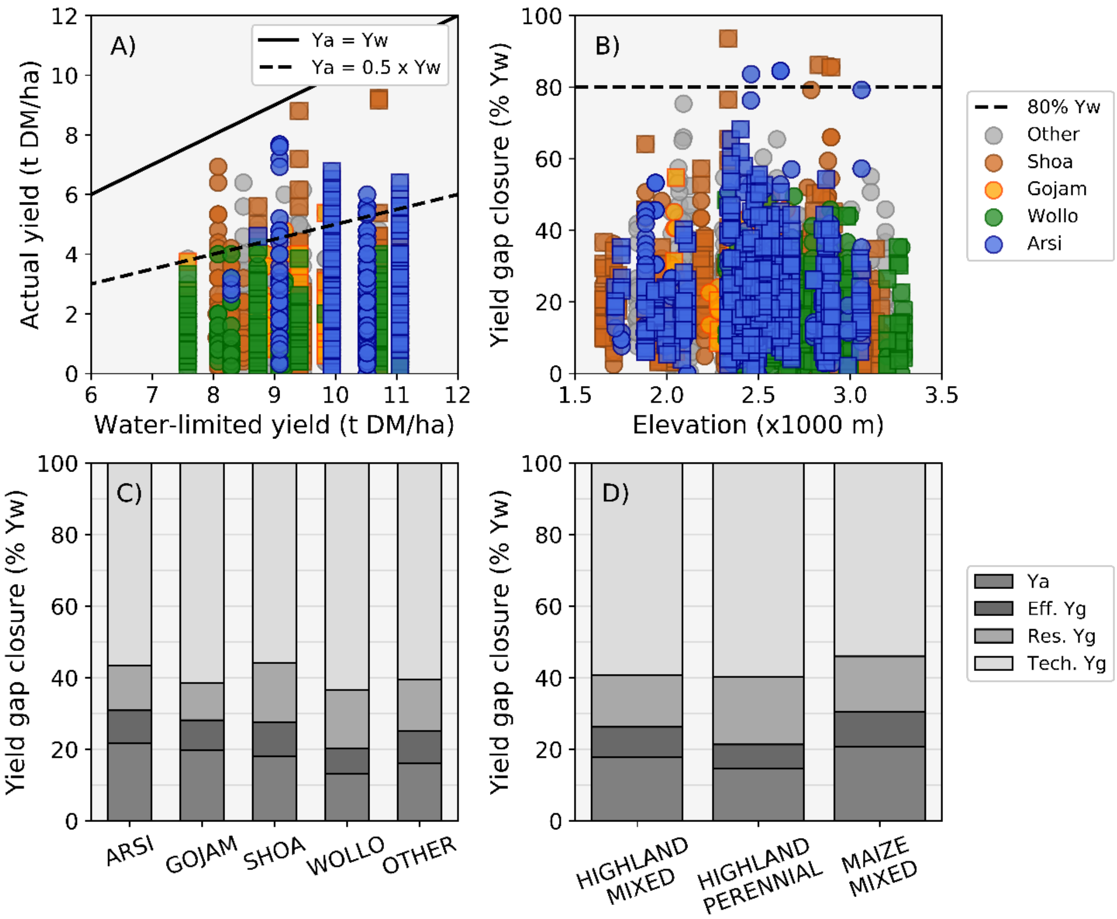

Figure 1. Wheat yield gaps in the Ethiopian highlands: A) relationship between actual yield and water-limited potential yield, B) yield gap closure in relation to elevation, C) yield gaps disaggregated by administrative zone and D) yield gaps disaggregated by farming system. Data refers to the years 2011 and 2013.

The magnitude of the efficiency (<10% Yw), resource (10 – 15% Yw) and technology yield gaps (>55% Yw) was also rather similar across administrative zones and farming systems (Figure 1C, D). Narrowing the efficiency yield gap through fine tuning of current practices (e.g., improved time, space and form of the inputs applied) would lead to increases in Ya of ca. 30%. Similarly, narrowing the resource yield gap through greater use of inputs would increase Ya by ca. 35%. It is worth nothing that seed and N rates were significantly greater for Y_{HF} than for average and lowest yielding fields (data not shown). Finally, the large technology yield gap suggests that major transformative changes are needed to increase wheat yields considerably in the country.

Conclusions

Yield gaps for wheat in the Ethiopian highlands are very large, with farmers' yields reaching on average only 20% of their water-limited potential. This is true across different administrative / agro-ecological regions and farming systems as well as across different years. Narrowing efficiency and resource yield gaps could more than double current Ya in some regions. However, the vast proportion of the yield gap (> 55% Yw) is attributed to the technology yield gap, meaning technologies used by farmers do not match best agronomic practices.

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