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Ethiopian Economics Association

Issue No. 02, November 2017

EEA Research Brief

Reducing The Maize Yield Gap In Ethiopia: Analysis And Policy Simulation

1. Introduction

Ethiopia can be considered a success story for maize production as, apart from South Africa, it is the only country in Sub-Saharan Africa that has shown substantial progress in maize productivity and input use.[i] After a period of limited growth, yield more than doubled from around 1.5 ton/ha in 2000 to over 3 ton/ha in 2013. Despite the recent progress in productivity, yield levels in Ethiopia are still very low relative to what could be produced. Data from the Global Yield Gap Atlas (GYGA) shows that the average maize yield gap in Ethiopia is 82%.[ii] The yield gap is defined as the difference between (water-limited) potential yield and actual yield. [iii] Potential yield is the maximum yield that can be produced on a parcel of land given agro-climatic conditions, assuming either rainfed or irrigated conditions. The conventional yield (Yg) gap can be decomposed into four elements that each reflects different causes of below potential yield (Figure 1).[iv]

2. Assessing the maize yield gap in Ethiopia

The various yield levels can be assessed jointly to decompose the total yield gap into the four aforementioned components (Figure 2). Using nationally representative household survey data for 2013 and 2015, it is found that the economic yield gap makes up the largest (40%) component of the yield gap, followed by the technology yield gap (38%), the allocative yield gap (11%) and the technical efficiency yield gap (10%). This pattern is consistent across all regions. On the basis of this it can be concluded that the yield gap in Ethiopia is mainly caused by economic constraints. Farmers are not willing to move to more intensive production, and in particular higher fertilizer application rates because of cost considerations. This also explains why most farmers are not using the recommended fertilizer and seed rates (119 kg N/ha and 25 kg/ha of hybrid seeds), which are simply not profitable at the present combination of maize and input prices.

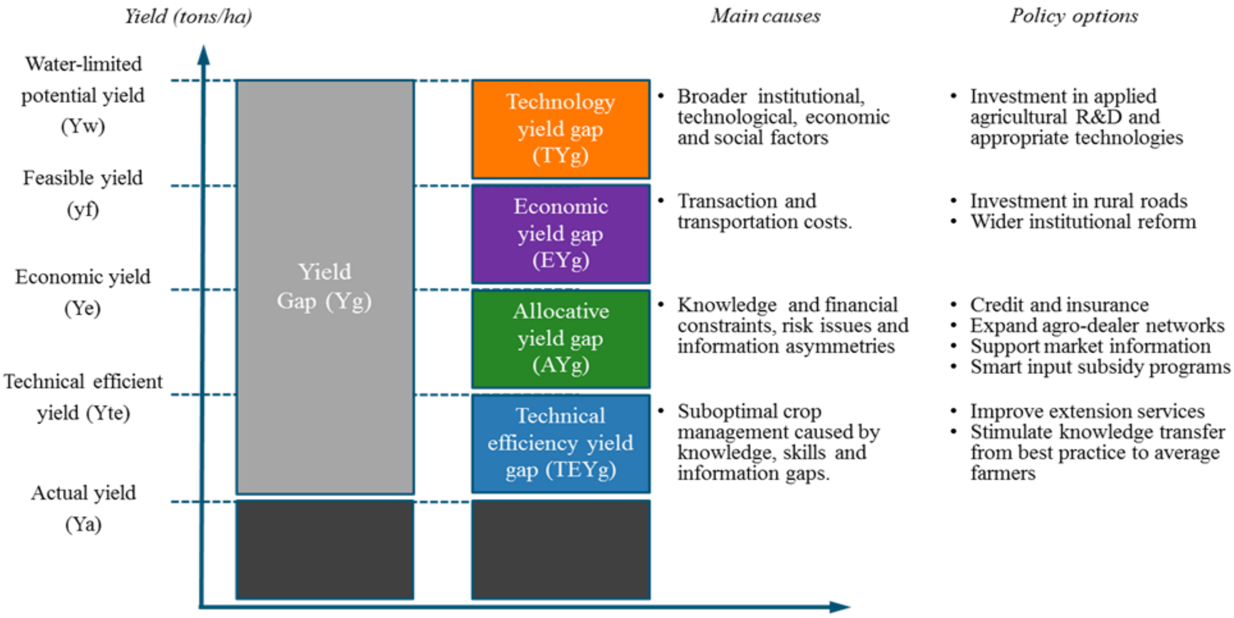

Figure 1: Yield gap decomposition, causes and policy options

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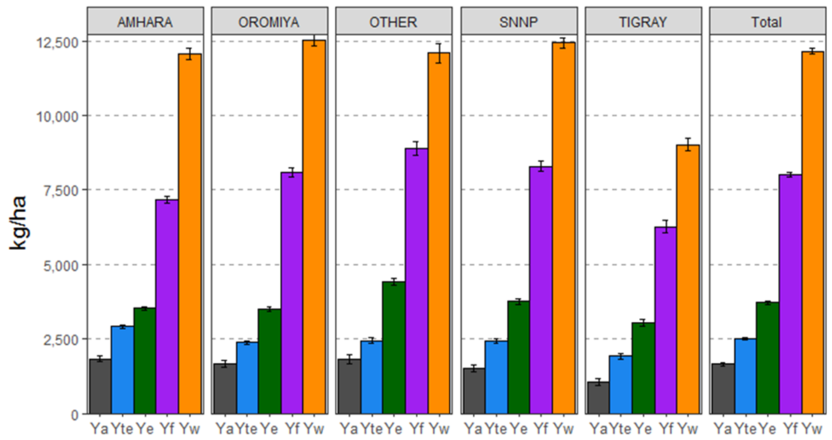


Figure 2: Yield levels in six districts, with actual yield (Ya), technical efficient yield (Yte), economic yield (Ye), feasible yield (Yf) and water-limited potential yield (Yw).

Economic Knowledge for Optimal Decision!

Figure 3 shows by how much national maize production in Ethiopia can be increased if the maize yield gap(s) can be closed. According to FAOSTAT, national maize production in Ethiopia is on average 6.7 million tons for the period 2013-2015 (present production). The analysis shows that relieving economic constraints would have the greatest contribution to maize production, although improving efficiency of input use, more efficient markets and adoption of advanced technologies will also result in higher national production The figure also shows the impact on total maize production if fertilizer prices would be halved and in case all farmers would implement the extension service recommendations, both adding around 4.3 million tons of total maize production.

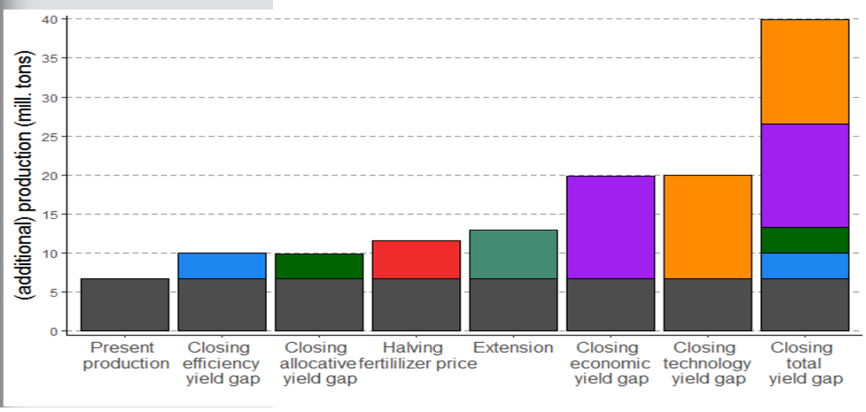
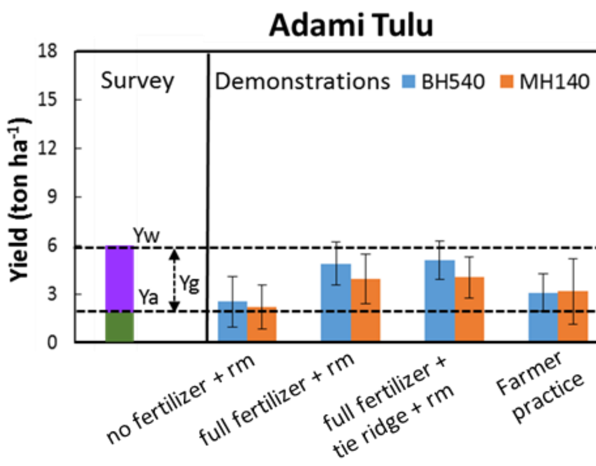


Figure 3. Increases in national maize production if yield gap(s) can be closed.

3. National policy recommendations

On the basis of the yield gap decomposition, a number of policies will contribute to closing the maize yield gap in Ethiopia and increase national production.

- Reducing the costs of inputs, for example by tax exemptions, investing in road infrastructure (transport costs make up 70% of the farm gate price averaged over regions and fertilizer types)[v] or the local production of fertilizer[vi], has the potential to narrow the economic yield gap substantially.
- Improving the effectiveness of extension services will contribute to closing the technical efficiency gap. Expansion of extension services is regarded as a key success factor behind the rapid increase in yield over the past decade. [vii] Others, however, have pointed out that the effectiveness of these services can be improved. [viii] Although our analysis did not address this issue specifically, we find that current extension recommendations are not affordable at present input and output prices and therefore, potentially, require revision.
- Addressing knowledge deficits of farmers, financial constraints, and risk and information constraints will help closing the allocative yield gap.
- Stimulating the diffusion of advanced technologies, such as integrated nutrient management, precision agriculture and improved varieties will contribute to closing the technology gap.



4. Local analyses in Central Rift Valley and Western Oromia

A local case study analysis can shed more light on the effects of crop management, farm characteristics and socio-economic conditions on maize yields and yield gaps. Farm surveys(2015 and 2016)and demonstration experiments(2016 and 2017) were conducted in the districts Adami Tulu Jido Kombolcha (hereafter Adami Tulu), located in the Central Rift Valley, and Bako Tibe, located in Western Oromia. These districts represent two major maize growing regions in Ethiopia with contrasting climatic conditions.

Results from the farm survey data of 2015 and 2016 showed that the average actual farmers yield was 1.6 ton ha^{-1} in Adami Tulu, and 4.2 ton ha^{-1} in Bako Tibe. Analysis of this data revealed that, out of many factors influencing maize production, an increased seed input had the largest effect in Adami Tulu, while in Bako Tibe an increased use of fertilizers had the largest effect. Our analysis did not reveal clear differences in crop management for farms with different characteristics. The average water-limited potential yield was 6.0 t/ha in Adami Tulu and 15.8 t/ha in Bako Tibe for the 2015 and 2016 seasons, which was estimated with Hybrid Maize crop growth simulation model. In Adami Tulu, actual and water-limited potential yields were highly affected by drought, especially in 2015. Farmers mentioned that the drought caused food insecurity and malnutrition of children in several households. In addition, it also affected the performance of their livestock, because no feed was available. The maize yield gap was on average 4.3 ton ha^{-1} in Adami Tulu and 11.5 ton ha^{-1} in Bako Tibe for 2015 and 2016 season, representing a relative yield gap of 73% for both (left panels in Figure 4).

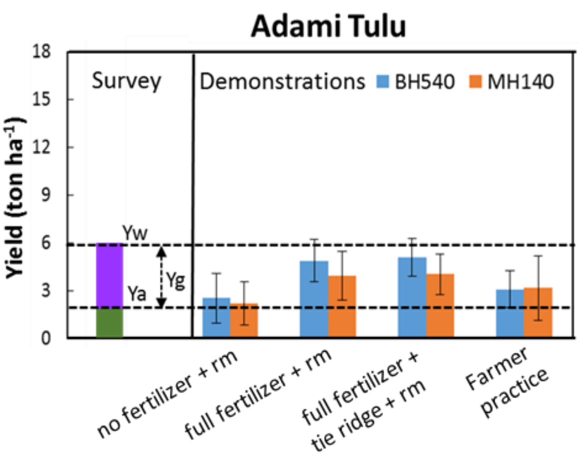


Figure 4: Left panels of the figures present the average farmers actual yield (Ya), water-limited potential yield (Yw) and the yield gap (Yg) for Adami Tulu and Bako Tibe resulting from the analysis of farm survey data of 2015 and 2016 and crop growth simulations for these years. Right panels of the figures present maize yields for the different maize varieties with the different treatments (rm stands for recommended management, i.e., recommended planting density and optimal weeding) as measured in the demonstration experiments in Adami Tulu and Bako Tibe in 2016.

A demonstration experiment in both Adami Tulu and Bako Tibe showed that fertilizer use had a positive impact on yield. Recommended management (recommended planting density and optimal weeding) in combination with the use of full fertilizer resulted in a higher yield in Adami Tulu compared to farmer practice, while this was not evident in Bako Tibe. This was, because in Bako Tibe the full fertilizer treatment had a lower fertilizer application rate than what most farmers already use. The effect of improved cultivars differed per district and per fertilizer practice (Figure 4). During the field day in Adami Tulu (Figure 5), the main observations of the farmers was that the new improved variety MH140 was performing well during drought conditions in terms of grain filling, early mature, and drought and disease resistance as compared to variety BH540 which they generally use and gives higher yield during good years. Farmers in Adami Tulu also mentioned that the fertilizer rate they generally apply is much lower than the recommended rate, which is because of economic reasons, as also shown in the national analysis. Tied ridges conserve moisture and alleviate drought conditions in areas like Adami Tuli.

Figure 5. Pictures of farmers visiting the demonstration experiment during the field day in Adami Tulu ***(picture credits Kindie Tesfaye)***

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5. Regional and local policy recommendations

From the case study analyses some further policy recommendations complementing the national ones (see above) can be derived:

- Availability and access to improved seeds can contribute to yield gap reduction (Adami Tulu).
- Affordable fertilizer prices are likely to contribute to substantial yield improvements
- Improving farm management practices (e.g., weeding, plant population, tied ridges for moisture conservation) through the extension services could enhance yield, reduce yield gaps and contributes to a better farmer resilience under different climatic circumstances.

IMAGINE project

The 'Integrated Assessment of the determinants of Maize yield gap: towards Innovation and Enabling policies' (IMAGINE) project uses a framework that integrates agronomic and economic approaches to assess maize yield gaps and analyse agricultural performance at the plot and farm level. IMAGINE is funded by the DFID-ESRC Growth Research Programme under research grant ES/L012294/1. The project is coordinated by Wageningen University & Research and implemented in Ethiopia by Ethiopian Economic Policy Research Institute (EEPRI) and the International Maize and Wheat Improvement Center (CIMMYT). Please contact prof. Martin van Ittersum (martin.vanittersum@wur.nl) for more information.

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[i] Abate, T., et al. (2015). Factors that transformed maize productivity in Ethiopia. Food Security, 7(5), 965–981. http://doi.org/10.1007/s12571-015-0488-z

[ii] http://www.yieldgap.org

[iii] van Ittersum, M.et al.(2013). Yield gap analysis with local to global relevance-A review. Field Crops Research, 143, 4–17. http://doi.org/10.1016/j.fcr.2012.09.009

[iv] van Dijk, M. et al. (2017). Disentangling agronomic and economic yield gaps: An integrated framework and application. Agricultural Systems, 154. http://doi.org/10.1016/j.agsy.2017.03.004

[v] Rashid, S. et al. (2013). Fertilizer in Ethiopia: An assessment of policies, value chain and profitability (IFPRI Discussion Paper No. 1304).

[vi] Recently, a project to build a 2.5 million tons fertilizer plant in Ethiopia has been launched (http://addisstandard.com/ethiopia-morocco-build-mega-fertilizer-production-plant [accessed 17-11-2017])

[vii] See Note i.

[viii] Spielman, D. J. et al. (2010). Policies to promote cereal intensification in Ethiopia: The search for appropriate public and private roles. Food Policy, 35(3), 185–194. http://doi.org/10.1016/j.foodpol.2009.12.002