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Short communication

Prospects for sustainable intensification of soybean production in sub-Saharan Africa

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Abstract

There is a significant soybean yield gap in sub-Saharan African (SSA) countries. Sustainable intensification of the agricultural sector to reduce such a yield gap is important. Increasing soybean productivity can meet the growing demand for food and feed when complemented with higher soy meal demand by the local livestock industry. This study performs an ex-ante economic analysis to determine the effect of higher soybean production on trade and land use within SSA countries. We find that increasing soybean yield by 50% can increase the total returns from soybean production by 186 million LC (local currency) in Ethiopia and 36 billion LC in Nigeria. We show that soybean yield growth alone is enough to boost soy oil production, as the crushing of the beans produces 18% oil and 79% meal. While increasing productivity may lead to freeing land to produce high-valued cash crops, investors will be reluctant to invest in the crushing facilities in the absence of soy meal demand by the livestock industry. Therefore, policymakers need to establish collaboration between development organisations, private companies, farmers and researchers to achieve this transformation and thereby raise agricultural productivity.

Key words: soybean yields; livestock; land-use change; sustainable intensification

1. Introduction

Food security is an urgent global issue, with the world population expected to surpass nine billion by 2050 (United Nations Department of Economics and Social Affairs 2017). It is a very severe issue in Africa and is affected by a combination of factors. One of the factors is lower crop yields. There is a substantial crop yield gap between the developed and developing countries (Neumann *et al*. 2010), and it is persistent among sub-Saharan African farmers (Nin-Pratt *et al*. 2011; Tittonel & Giller 2013; Dzanku *et al*. 2015). This crop yield gap is primarily due to the under-use of modern inputs (e.g. irrigation, fertiliser) and advanced seed varieties in developing countries (Foley *et al*. 2005), which in turn is a consequence of low prices and a lack of access to markets for agricultural produce (Neumann *et al*. 2010). The premise being set, reducing yield gaps is challenging due to the lack of availability and higher cost of fertiliser in sub-Saharan African (SSA) countries.

While major grain crops require a significant amount of fertiliser, soybean with nitrogen fixation can grow with less fertiliser. In addition, soybean has a high protein and oil content, making it favourable for human food, feed use and for manufacturing industrial products, including biodiesel. Hence, soybean with high nutritional value and a nitrogen-fixation capability could be a major crop in SSA. Like other agricultural commodities, soybean yields in African countries are substantially lower than in developed countries. The average yield of soybean in Ethiopia from 1993 to 2017 was 1.21 MT per hectare, while in Mali, Uganda and Nigeria it was 1.21, 1.28 and 0.94 MT respectively in the period from 1990 to 2017. The average yield was 1.65 MT per hectare in Ghana from 2013 to 2017, and the world average yield from 1990 to 2017 was 2.30 MT per hectare (FAOSTAT 2019) (as shown in Figure 1).

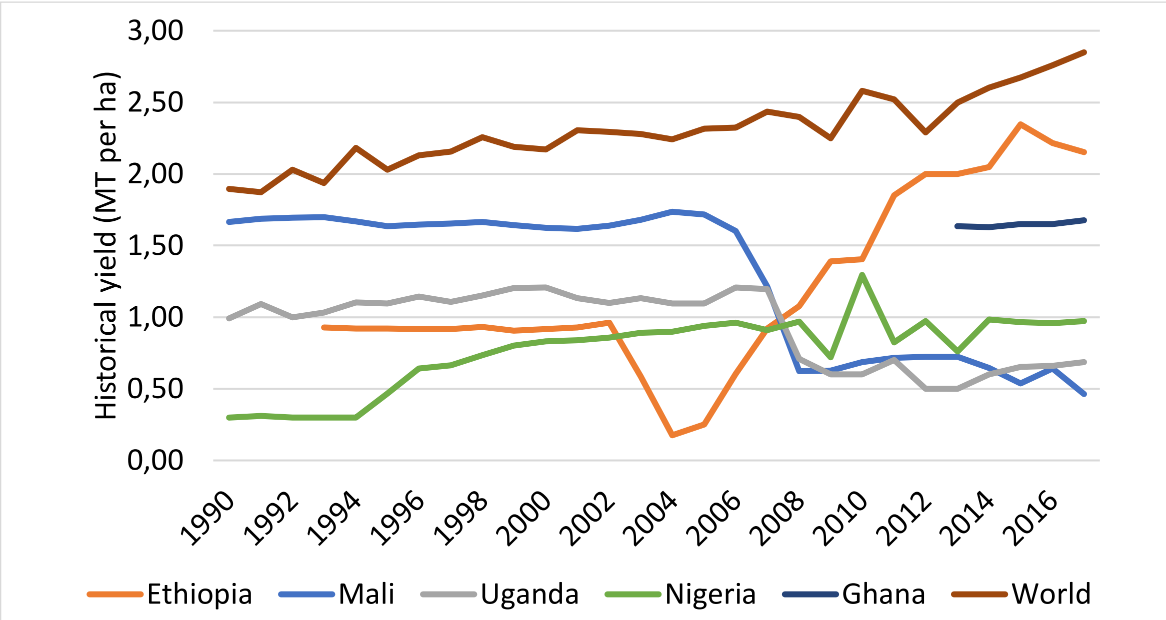

Figure 1: Comparison of historical average soybean yield between sub-Saharan African countries and the world

Source: FAOSTAT (2019)

There are strategies that can be used to reduce this yield gap, including crop rotation and the utilisation of modern technologies and high-yielding crop varieties. However, in the absence of alternative uses of soybean or the land that has been freed due to productivity growth, farmers are less willing to adopt yield-increasing varieties, technologies and production practices, which are anticipated to lower prices and land value. Klümper and Qaim (2014) found that the adoption of genetically modified (GM) technology increases yields by an average of 22% relative to traditional varieties, and that the effect is more prominent in developing countries. Barrows *et al*. (2014) estimated that the introduction of GM varieties increased the global supply of soybean by 30%. Acevedo-Siaca and Goldsmith (2019) summarised the potential benefits of soybean-maize rotation in SSA. Franke *et al*. (2018) conducted a literature review and showed that a sustainable agricultural intensification in SSA through a grain-soybean rotation increased soybean yield by 50%, while Mutegi and Zingore (2013) estimated that, in Uganda, the implementation of integrated soil fertility management (ISFM) technologies increased soybean yield by 100%. However, these studies did not discuss the consequences of the yield increases on farmers' profitability.

2. Data and methodology

In this study, based on the FAO's soybean yields, the area under production and export volume, we performed an ex-ante economic analysis of the effect of higher yields on domestic soy oil and meal production and the influence of this on trade and land use in five SSA countries: Ethiopia, Ghana, Mali, Nigeria and Uganda. We argue for three options that incentivise producers to increase soybean yields without hurting prices. First, we discuss how increasing the SSA countries' soybean productivity makes them self-resilient by reducing their dependence on foreign supplies. Furthermore, we evaluate the opportunity to produce soybean oil-based biodiesel as a substitute for fossil fuels. Lastly, we show that, with increasing soybean productivity, farmers may divert some portion of their land to grow other cash crops, including cocoa.

We analysed the effect on domestic soybean and oil production and import, the conversion of oil to biodiesel, and the land-use change. The assumption is that soybean yield in five major SSA countries will improve by 50% due to a combination of the adoption of high-yield varieties, the implementation of sustainable intensification, and the use of integrated soil fertility management (ISFM) technologies (as shown in Figure 2).

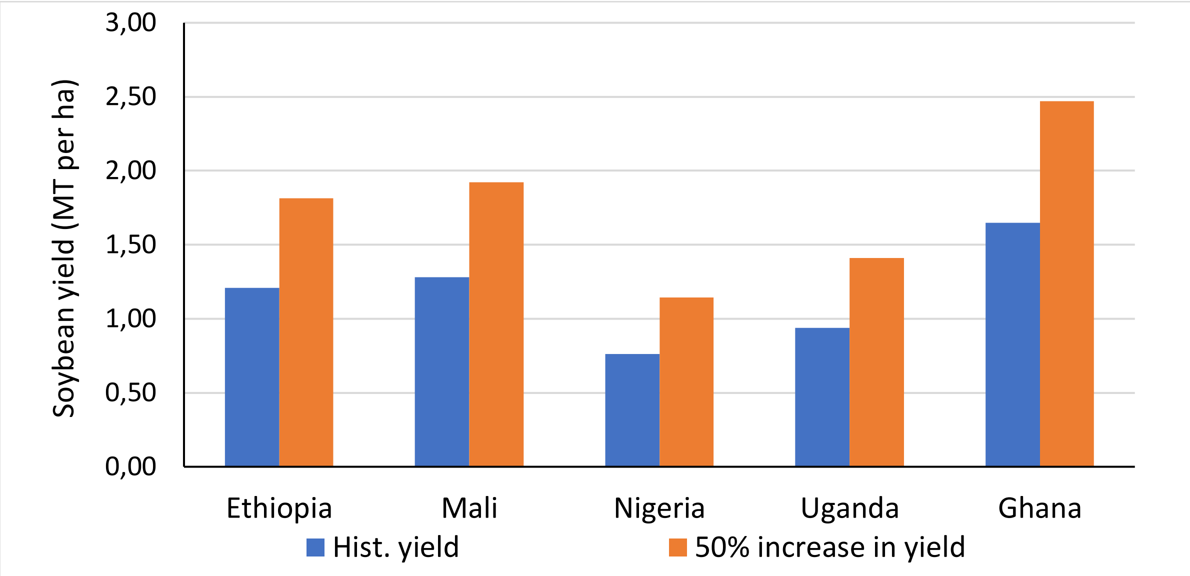

Figure 2: Comparison of soybean yield between average historical yield levels and 50% higher
Source: FAOSTAT (2019) and authors' calculations

3. Results and discussion

We found that a 50% increase in soybean production in 2017 resulted in 426 000 MT of extra soybean and 76 000 MT of oil[1] in the five SSA countries (Ethiopia, Ghana, Mali, Nigeria, and Uganda), making them self-reliant in soy oil production. For example, in 2017, Mali import 0.71 thousand MT of soy oil. After the 50% yield improvement, they can produce 1.94 thousand MT additional soybean oil and subsequently will not rely on foreign countries to meet their domestic soy oil demand. Ethiopia, in the absence of domestic crude oil production, is entirely dependent on imports. The country can convert the additional 4.2 thousand MT of soy oil into 4.1 thousand MT of biodiesel annually, which will significantly improve its fuel security and save foreign exchange, without diverting land from existing food production. However, farmers in Nigeria, a net exporter of soybean and a major crude oil producer, may not be willing to adopt yield-increasing technologies. In this case, soybean production may continue at the 2017 level with an increasing yield, while farmers can grow cocoa on the newly idle 250 000 hectares of land (as shown in Figure 3). This will increase farmers' overall return from the existing land.

[1] 1 MT of soybean is crushed into 79.2% meal and 17.8% oil (https://ussec.org/resources/conversion-table/).

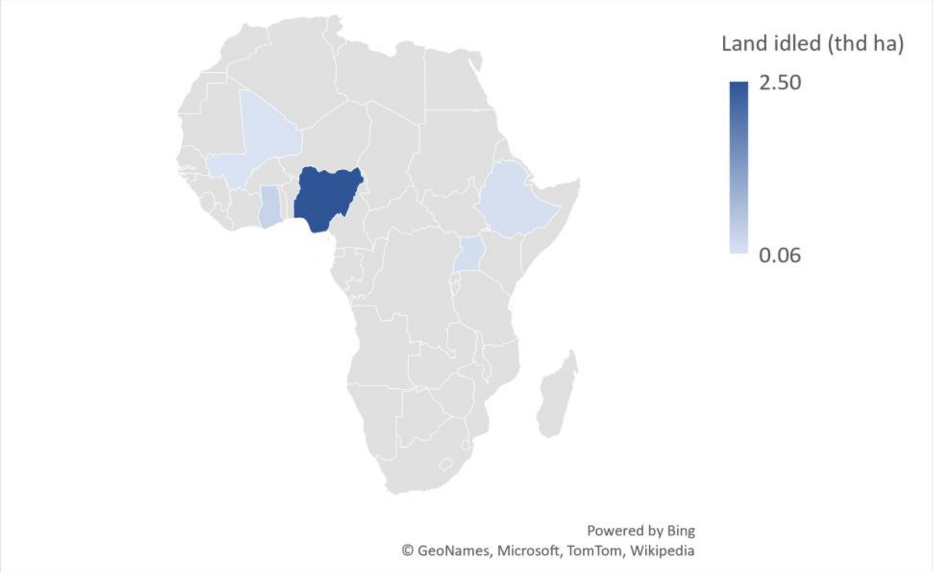

Figure 3: Spatial map of land that has become idle in Africa due to a 50% growth in soybean yield

Source: Authors' calculations

However, increasing soybean yield alone will not meet the growing food and feed demand in SSA countries. The competitive advantage of soy lies in the complementarity of meal and oil use. Unlike Asian, South and North American countries, where the success and dominance of soybean production depend on strong demand for the feed meal by the poultry and swine industries, the livestock industry in SSA countries is at a nascent stage. As the crushing of soybean produces only 18% oil and 78% meal, processing soy only for oil is expensive for crushers in the absence of a domestic demand for soy meal (cake). For instance, due to the lack of crushing infrastructure, Ethiopia exported 53.94 thousand MT of soybean and imported 4.52 thousand MT of soy oil in 2017 (FAOSTAT 2019). Moving forward, significant infrastructure investment, along with the adoption of sustainable intensification in soybean-processing facilities and in the livestock industry, is critical to the transformation of the agricultural sector in SSA. This transformation may have substantial benefits by increasing soybean yield, reducing dependence on foreign soy oil supplies, increasing livestock production, and rejuvenating the rural sector by producing highly valued industrial products, including biodiesel.

Increasing soybean yield and the utilisation of soybean cake to feed the domestic livestock industry can substantially increase the returns from soybean, oil and cake. In the absence of relevant price data for other SSA countries, we estimated the changes between producers' return with and without yield growth for Ethiopia and Nigeria[2] (Figure 4). If soybean yield increases by 50%, Ethiopian and Nigerian soy producers' total returns will increase by 186 million LC (local currency) and 36 billion LC, respectively. Simultaneously, processors will also receive a higher return, which will increase by 189 million LC (66 million LC from oil, 123 million LC from cake) in Ethiopia, and by 36 billion (13 billion LC from oil, 23 billion LC from cake) in Nigeria. Therefore, increasing soybean productivity in sub-Saharan Africa may substantially affect the welfare of the small farmers. However, it depends on how quickly the SSA countries generate sufficient demand for soy oil and animal feed.

[2] Soybean price data was obtained from the OECD-FAO agricultural outlook (https://stats.oecd.org/viewhtml.aspx?QueryId=91992&vh=0000&vf=0&l&il=&lang=en). In the absence of country-specific soy cake and oil data, we extrapolated the oil price as twice the price of beans, and the cake price as 0.83 times the price of beans (http://www.fao.org/3/bt312/bt312.pdf).

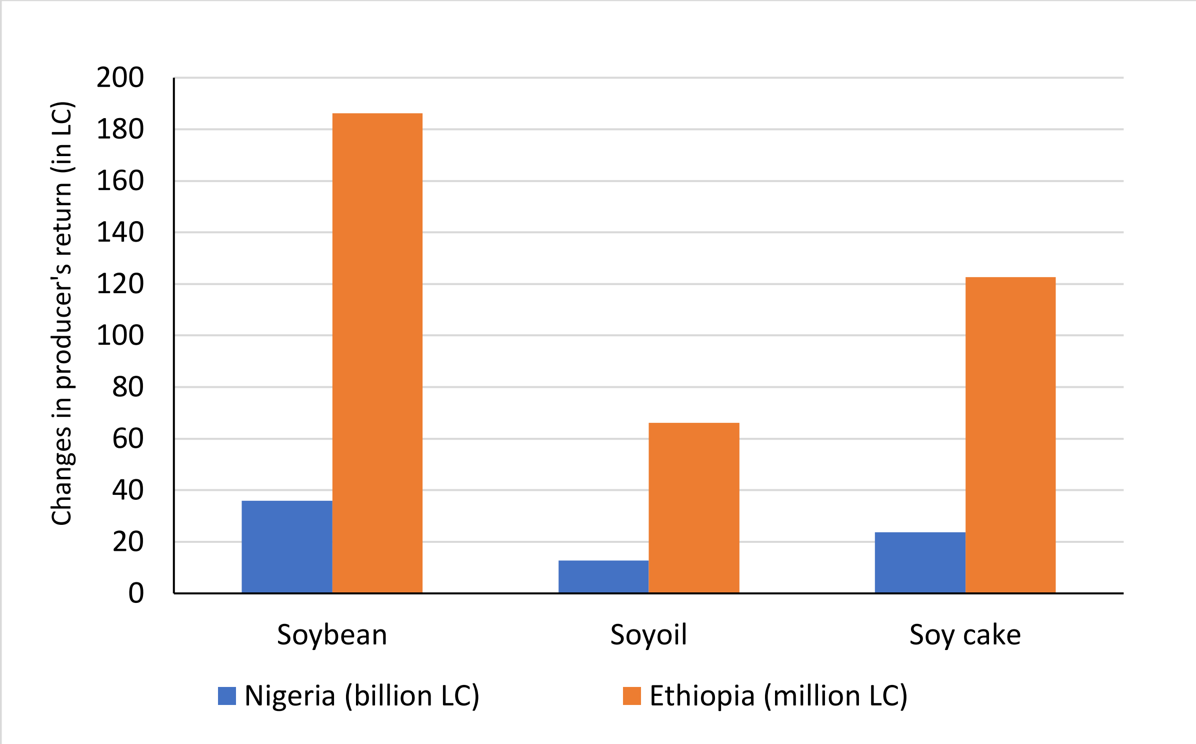

Figure 4: Increase in soy producers' and processers' returns due to a 50% increase in soybean yields

Source: Authors' calculations

4. Policy implications

Policies that encourage the sustainable intensification of agriculture and reduce yield gaps across the SSA countries can increase food and feed production without adversely affecting the environment. However, this requires institutional partnerships between governments, the private sector and development banks to invest in soybean-crushing infrastructure and biorefineries, and in the reallocation of the recently idle land due to yield growth from traditional crops to alternative cash crops. Conceivably the biggest challenge is to establish the new institutional initiatives that would allow the transformation of the agricultural sector in many SSA countries toward implementing ISFM technologies and sustainable agricultural practices that rely on modern technologies and enhanced human capital in the farm sector. Collaboration between development organisations, private companies, farmers and researchers is essential to achieve this transformation and to raise agricultural productivity to what is necessary to feed the increasing population of the SSA countries.

Many of the sub-Saharan African countries dealing with high population growth have realised the importance of embracing transformation and modernisation of the agricultural sector, which will increase their productivity. For instance, in 2010, the government of Uganda initiated the Vegetable Oil Development Project.[3] The project is providing oilseed-producing farmers support to increase their crop yields and is helping them with the value chain development of soybean and other oilseed crops. However, the increase in production is mainly due to the expansion of farmland, as productivity growth in the agricultural sector has been stagnant since 1970 (Khojely *et al*. 2018). Thus, transforming agriculture to the extent necessary to increase productivity can lead to moving it up the value chain. The development of the value chain, along with increasing productivity among soybean producers, could be a real game-changer for the small-scale farmers in the rural communities of SSA. The implications of such projects or policies are beyond agriculture. In Mali, while the country surpassed the 6% growth in agricultural productivity recommended by the Comprehensive Africa

[3] https://www.agriculture.go.ug/vegetable-oil-development-project-vodp2/

Agriculture Development Programme (Feed the Future 2018), it bolsters food security, nutrition, climate change adaption and resilience.

In many of the sub-Saharan countries, there is substantial potential to increase the soybean yield by introducing high-yield varieties and mechanised farming. However, smallholdings and customary tenure present serious threats to such development. Unlike developed countries, the agricultural extension systems in Africa are constrained by limited resources, which consequently restrain their influence on the output. Furthermore, climate change is increasing the vulnerability of rural SSA farming communities, who are also food insecure. While these countries have seen increasing R&D spending on agriculture, the lack of productivity growth indicates significant challenges in growing those varieties productively in the field, resulting in a key concern regarding the efficient linkage between various institutions and research agencies within SSA's agricultural innovation system. Addressing these challenges requires some form of association among the governments of the SSA countries, international organisations and foreign aid agencies. Therefore, without coordinated action on common issues faced by the sub-Saharan African agricultural sectors, such as low productivity, climate change, food insecurity, human capacity development and funding, outcomes will be suboptimal, dispersed and fragmented.

In this study, we have shed some light on the fact that only increasing agricultural productivity is not enough to reduce food insecurity among SSA countries. Moreover, achieving food security also requires institutional development and public-private partnerships. While we showed that increasing soybean productivity would lead to higher returns, the effect of this on producer profitability is unknown, as it is driven by the increase in production costs related to the adoption of new varieties and technologies. The price effect on soybean and co-products is also unknown, and this needs to be addressed as it drives many decisions at the farm level, including production, consumption and trade. Therefore, in the future, we plan to perform econometric analysis and simulation modelling exercises to analyse the effect of such a yield shock on both the demand and supply sides of the economy, including the agricultural, livestock and bioenergy sectors.

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