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Discussion

Local fertilizers to achieve food self-sufficiency in Africa

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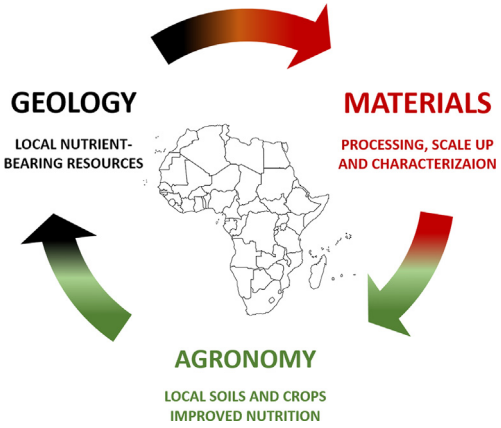
GRAPHICAL ABSTRACT



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ABSTRACT

One of the key Sustainable Development Goals (SDG) set by the United Nations (UN) aims by 2030 to "*end hunger, achieve food security and improved nutrition and promote sustainable agriculture*". Fertilizers will play a pivotal role in achieving that goal given that ~90% of crop production growth is expected to come from higher yields and increased cropping intensity. However, materials-science research on fertilizers has received little attention, especially in Africa. In this work we present an overview of the use of fertilizers in Africa to date, and based on that overview we suggest future research directions for material scientists. Developing a new generation of local and affordable fertilizers will launch Africa into a new phase of remunerative agricultural production that in turn will lead to both food self-sufficiency and considerable progress towards goals of food and nutrition security.

1. Introduction

As of 2018, food security remains a key global challenge. According to the Food and Agriculture Organization of the United Nations (FAO) an estimated 815 million people are currently suffering from

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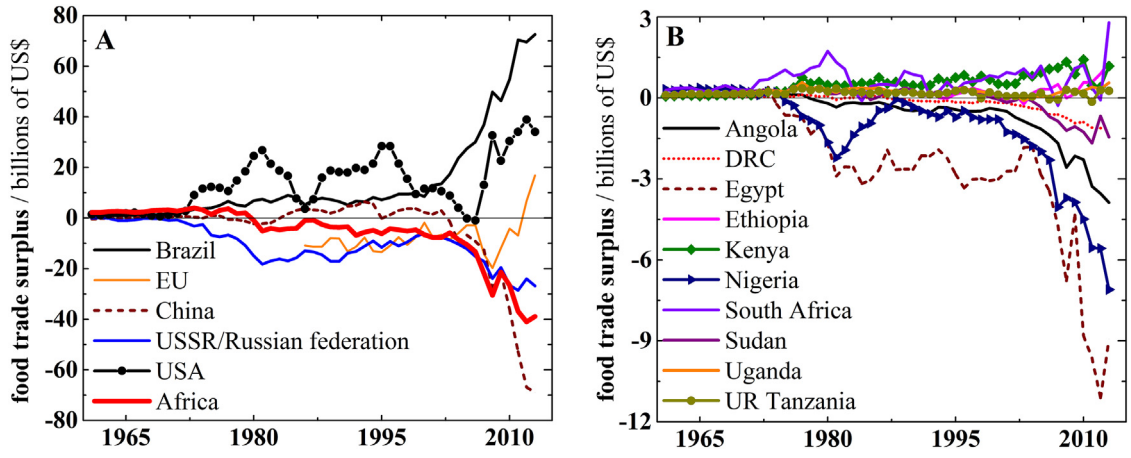

Fig. 1. Value of food trade surplus (food exports minus food imports) in billions of US$ for (A) selected countries or regions and (B) the ten African countries forecast to have the largest population in 2050. EU data starts in 1986 and refer to extra-EU trade only; Ethiopia data starts in 1993; USSR data are up to 1992 and continued with Russian Federation data; *former Sudan* (up to 2011) and *Sudan* are shown simply as Sudan.
Source: FAOSTAT.

undernourishment (FAO, 2017a). Africa is the continent with the highest number of undernourished people with respect to total population, although the highest absolute number is found in Asia (519.6 M). In 2014, undernourishment as high as 55% was reported for the Central African Republic (CAR), followed by 46% for Zambia and ~41% for Zimbabwe and Liberia. The continent-wide average corresponded to ~18%, equivalent to 209.5 million people (Supplementary Material S1).

Root causes that generate undernourishment in Africa include diffuse poverty and conflicts, failed states, a changing climate, malnutrition and a generally low agricultural productivity (AAVV, 2001; FAO, 2017b; Sasson, 2012). Additionally, a key complicating factor is the continuing and rapid population growth originating from both improved public health and a limited approach to family planning (Bongaarts and Casterline, 2013). Africa will contribute to ~58% of the world population growth to 2050, and will host by then ~2.5 billion people, roughly a fourth of the world population. Nigeria will top by far any other African country with an expected 410.6 M people, followed by the Democratic Republic of Congo (DRC) (197.4 M) and Ethiopia (190.9 M). The largest rural population will be concentrated in Nigeria (144.9 M), Ethiopia (117.1 M) and Uganda (70.7 M) (Supplementary material S1).

To tackle such a massive demographic change no single solution is available and innovative approaches to food production will have to be found. One area of relative consensus is that *local* food production will need to increase substantially, to reduce or at least maintain current food prices in a context of rapidly increasing demand. Currently, Africa imports ~40% of the food value consumed (FAO, 2017c; Rakotoarisoa et al., 2011; Sasson, 2012), in net contrast with the comparative advantage that derives from the combined availability of both land and a young workforce (Fig. 1A). Food imbalances between rural and urban areas are also reported (Rakotoarisoa et al., 2011). Reliance on foodstuff imports is not necessarily an issue if it is due to an economy that specializes in services or high-value goods. However, that is not the case for most African countries, which should strive for food self-sufficiency to become less susceptible to shocks in foreign-food supplies and to avoid purchasing international currency for payment of food imports (Marchand et al., 2016; van Ittersum et al., 2016). Among countries with the largest population forecast, Egypt, Nigeria and Angola face the most substantial food deficit whereas Kenya, Ethiopia and South Africa the most substantial food surplus (Fig. 1B).

Fertilizers are important agricultural inputs at the base of the concept of food self-sufficiency, and will play a vital role in transforming African agriculture, although they may still be insufficient to feed Africa (AAVV, 2001; FAO, 2017b; Pradhan et al., 2014; Pradhan et al., 2015; Stewart and Roberts, 2012; van Ittersum et al., 2016; Vlek, 1990). Over the next 30 years, global food-production increases between 28% and 58% could be obtained alone by closing local yield gaps across the globe (Foley et al., 2011; Pradhan et al., 2014; Pradhan et al., 2015), with the future role of fertilizers evidenced by the fact they will be responsible for about 30%–50% of that expected yield

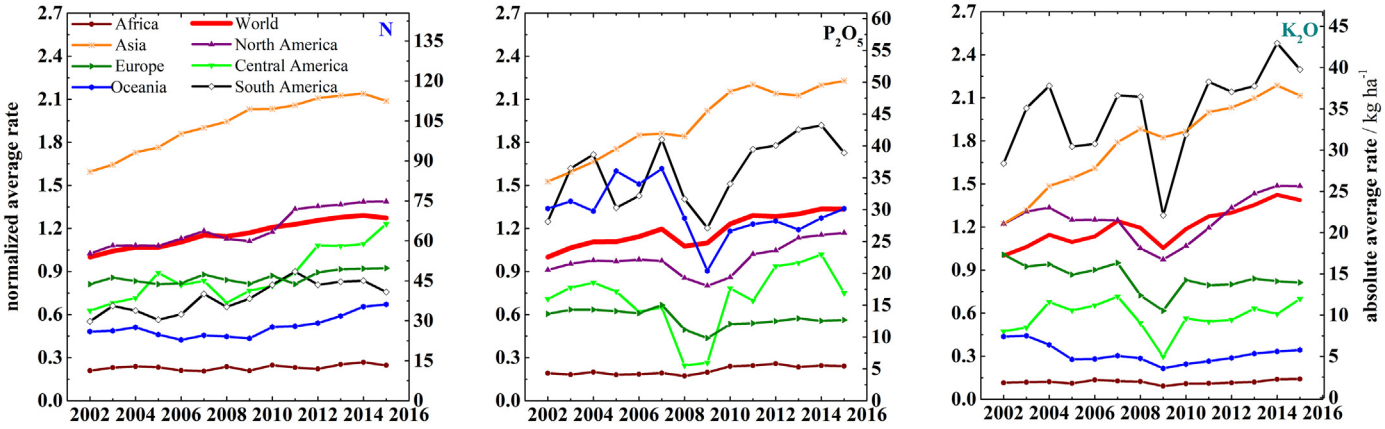

Fig. 2. Average fertilizer use (kg nutrient ha^{-1} cropland) per geographical area. Left axis is the normalized value to the world average in 2002; right axis is the absolute value.
Source: FAOSTAT.