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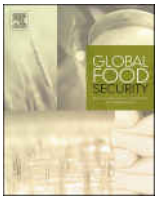

Grain legume production in Europe for food, feed and meat-substitution

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ABSTRACT

Partial shifts from animal-based to plant-based proteins in human diets could reduce environmental pressure from food systems and serve human health. Grain legumes can play an important role here. They are one of the few agricultural commodities for which Europe is not nearly self-sufficient. Here, we assessed area expansion and yield increases needed for European self-sufficiency of faba bean, pea and soybean. We show that such production could use substantially less cropland (4–8%) and reduce GHG emissions (7–22% current meat production) when substituting for animal-derived food proteins. We discuss changes required in food and agricultural systems to make grain legumes competitive with cereals for farmers and how their cultivation can help to increase sustainability of European cropping systems.

1. Introduction

It is widely understood that global food systems need to be transformed to reduce their substantial adverse environmental impacts, e.g., methane emission from livestock and N_2O emissions from fertilizer use at crops (Campbell et al., 2017). The production of meat-sourced proteins is of particular concern, as their environmental impact is around ten times greater on a mass basis and has CO_2 emissions around 30 times more than those of plant-based proteins (Poore and Nemecek, 2018). At the same time, there is currently increased interest in plant-based proteins, due to awareness that a protein transition from animal-to plant--based would enhance healthy and sustainable diets (Aiking and de Boer, 2020; Willett et al., 2019). Grain legumes are protein-rich and a good source of nutrients (Curran, 2012; Erbersdobler et al., 2017). It is estimated that European consumers would be willing to replace around a quarter of the meat consumption with grain legumes (Henn et al., 2022). The European-Commission (2020) is promoting EU-grown plant proteins within the Farm to Fork strategy as part of the European Green Deal

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in recognition of the environmental and health benefits associated with production and consumption of plant protein.

Currently, European demand for grain legumes, specifically soybean, is high and the European Union together with the UK imports about 14 million tonnes (Mt) of soy beans and 18 Mt of soy meal (Eurostat, 2023; FAO, 2023). Over 95% of the imported soybean is used for animal feed, and this is considered unsustainable from an environmental perspective because of the conversion inefficiency involved in animal production and because of (in)direct land use change in the soybean exporting countries. Domestic production of grain legumes should therefore increase (Zander et al., 2016). For the purposes of this analysis, we consider Europe to be all European countries west of Russia and Turkey.

Sufficient internal European production of grain legume crops is amongst the first steps in the protein transition. Faba bean (*Vicia faba* L.), pea (*Pisum sativum* L.) and soybean (*Glycine max* (L.) Merr.) are, by far, the three most widely grown grain legumes in Europe (Eurostat, 2023; Kezeya Sepngang et al., 2020). Yet, current harvested areas of those legumes are small, only ~2% of the European cropland is used for soybean cultivation and ~1% for pea and faba bean jointly (FAO (2023), average 2015–2020). This is in sharp contrast to cereals which cover 46% of the European cropland (FAO (2023), average 2015–2020). Increased European legume production could be realised by both intensification and/or area expansion. Intensification of current production has the advantage that it will not lead to competition for land use with the production of other food crops (although legumes can also be grown on marginal land (Gogoi et al., 2018)) nor to expansion into natural ecosystems. Initial estimations for soybean suggest relatively low production efficiency of grain legumes (51% of potential yields) in comparison to cereals (58% of potentials) in Europe (Schils et al., 2018; van Ittersum et al., 2023; Watson et al., 2017). At the same time, area expansion of legumes will lead to more diverse cropping systems, which is advocated by many (Francis and Clegg, 2020; Nemecek et al., 2008; Preissel et al., 2015). Additionally, due to climate change, significant areas may become more suitable for soybean production in the future due to climate change (Fodor et al., 2017; Nendel et al., 2023).

As a consequence, we devise two scenarios to increase grain legume production, (1.) narrowing the yield gap, i.e., the difference between what farmers actually produce (Ya) and the potential yield (Yp) in irrigated systems or the water-limited potential yield (Yw) in rainfed systems; and (2.) expanding the areas of grain legumes at current yield levels. In this study we will investigate how increased European grain legume (i.e., faba bean, pea, soybean) production, through either Scenario 1 or 2, could contribute to greater supply of plant-based protein and substitution of consumption of meat-based proteins, together with impacts on their land footprint and GHG emissions. We consider a relatively short time horizon in potential production scenarios, assuming no major genetic changes or climate change effects.

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