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Reducing the European Union's plant protein deficit: Options and impacts

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Abstract: The EU has a historical deficit of plant protein and is heavily reliant on imports to sustain domestic livestock production. Using an economic model of global agricultural markets, this article investigates three policy drivers that could have an influence on the increased production of protein-rich crops in the EU, namely coupled payments for protein-rich crops, investment in research and development leading to higher yields, and phasing out of imported high indirect land-use change risk biofuel feedstocks. Results indicate that a one per cent annual increase in yields over the medium-term has a much larger effect on EU domestic protein production than additional coupled payments of EUR 75 per ha. Moreover, phasing out palm-based biodiesel only has a small impact on protein self-sufficiency. A significant unknown is how costly it will be to increase the yields on protein crops grown in the EU.

Keywords: agricultural markets; economic modelling; indirect land-use change; protein payments; protein self-sufficiency; yield gaps

Legume crops play a key role in European agriculture and the food industry. Legumes are an important source of medium and high protein-rich feed in the animal husbandry industry. Their cultivation in Europe provides environmental benefits through improved soil fertility, reduced fertiliser use, and extends the range of varieties in crop rotations. Legume production also positively affects biodiversity in the agricultural landscape and contributes to climate change mitigation.

The EU currently has a deficit of protein feed and is heavily reliant on imports from the US and Latin America to sustain domestic livestock production. In 2017 and 2018, this issue gained momentum in the political discussion, which resulted in the European Soya Declaration – Enhancing soya and other legumes cultivation, which has been signed by 14 EU member countries (Council of the European Union 2017). The signatories support local, regional, national, and European initiatives to develop sustainable protein supplies that are highly accepted in consumer markets within the EU. The declaration highlights consumer interest in GMO-free products. It aims to increase locally adapted legume production using sustainable production techniques and locally adapted legumes. It also calls for additional support for the certification of sustainably produced soya beans and meal imported from other parts of the world to meet remaining demand.

In response to the political demand for initiatives to spur on legume crop cultivation in the EU, the European Commission (EC) undertook a report to the council and the European Parliament, which was published in 2018 (EC 2018a), on the development of plant proteins in the EU. Several existing Common Agricultural Policy (CAP) measures that can be used to support the production of protein crops are discussed in this report, including coupled support payments and indi-

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rect support under the rural development programmes in the form of research and development (R&D) for protein crops (Clément et al. 2018). The report also discusses how certain non-agricultural policies, e.g. the Renewable Energy Directive, can affect the production of protein crops. In particular, a side-effect of the 2018 recast Renewable Energy Directive [RED II – Directive (EU) 2018/2001] is that it could further boost protein-rich crop production within the EU, since it requires the phasing-out by 2030 of those biofuels produced from feedstocks with a high risk of inducing indirect land-use change (ILUC) (EC 2018b).

Building on this foundation, this article investigates the impact of three different policy drivers potentially incentivising the production of protein crops in the EU. First, the incorporation of coupled support for protein crops to the CAP. Second, the support of higher plant protein yields through investment in R&D (e.g. incorporation of new breeds and better management). Third, the phasing out of imported high ILUC risk biofuel feedstocks as part of the Renewables Energy Directive (RED II), assuming that this implies a complete phasing out of palm-based biodiesel in the EU. To understand the potential economic impacts of these drivers, a scenario analysis is presented using the Aglink-Cosimo model and the OECD/FAO Agricultural Outlook database (OECD/FAO 2020). The EU Agricultural Outlook report from 2018 (EC 2018c) contains a similar, albeit less detailed, analysis based on a previous baseline.

MATERIAL AND METHODS

The analysis in this paper is based on a recursive dynamic partial equilibrium model of the global agricultural markets called Aglink-Cosimo. It was developed by the OECD and FAO secretariats with the purpose of preparing medium-term (usually about ten years) agricultural market outlooks and providing an economic model for policy simulations. The model calculates the development of annual supply, demand and prices for the main agricultural commodities produced, consumed, and traded worldwide. In the present version, it covers 54 individual countries and regions, 93 commodities and 40 world market-clearing markets prices (Araujo Enciso et al. 2015; OECD 2015). For this article, the Aglink-Cosimo model version, released with the OECD/FAO (2020) agricultural market outlook, was used.

Figure 1 illustrates the composition of EU's protein feed consumption in 2020/2021. Roughage is the main source of protein and supplies 42% of the total protein consumed by livestock, followed by oilseed meals and cereals, which supply 26% and 21%, respectively, of the total protein consumed as feed. Within the oilseed meals complex, the use of soya bean meal dominates, accounting for 17% of total feed proteins. In terms of self-sufficiency, feed use of EU origin accounts for 76% of all feed proteins consumed, but notably, 97% of soya bean meals (or soya beans going into protein meal) are imported. In contrast, pulses (field peas, broad beans lupins) only accounted for 1% of total feed protein in 2020/2021, but 92% of this is grown within the EU.

The strong dependency on imported soya makes EU livestock farmers vulnerable to external conditions. There have been several 'protein plans' throughout the years aiming to increase the European self-sufficiency of feed proteins (Hache 2015). EU imported 36.6 million tonnes of soya bean equivalent in 2020/2021, with 15.7 million tonnes of soya beans imported for crushing into soya bean oil and meal, and 16.5 million tonnes of soya bean meal (20.9 million tonnes of soybean equivalent). That year, the domestic soya bean production was 2.6 million tonnes, and the EU soya bean area was just over 1 million ha. Furthermore, the vast majority of imported soya is produced from GMO seeds and in some regions of the world, soya has been produced on primary forestland, contributing to the global loss of forests ecosystems (Ruviaro et al. 2012; Castanheira and Freire 2013; Curtis et al. 2018; EC 2019b). When

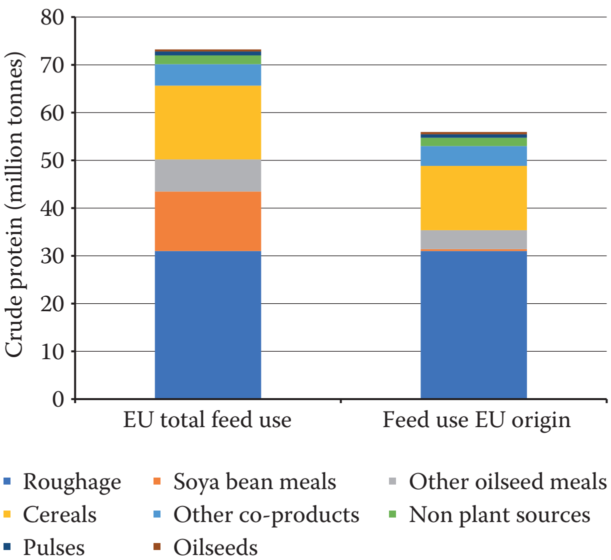

Figure 1. EU feed protein composition 2020/2021

Source: The figure is based on the EU Feed Protein Balance Sheet 2020/2021 published by the European Commission (EC 2021)

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the EC started exploring the potential for increasing the domestic production of plant protein in 2017 to reduce the import dependency, such concerns over the environmental impacts of importing large amounts of soya featured prominently among the arguments (European Parliament 2018).

The main finding of the recent explorations into the possibilities to increase EU production of plant proteins in general and non-GMO EU soya beans, in particular, was that the growth potential for EU soya bean production for the conventional compound feed market is limited (EC 2018a). The reason is that EU farmers have a comparative advantage in cereals production due to the relative low soya bean yield in Europe (EIP-AGRI 2014). EC (2018a) outlines several possible policy instruments, which could be used to stimulate EU production of plant protein, including the greening measure of the CAP, rural development programmes and coupled support. In the scenario analysis below, we compare and discuss the relative effects on the agricultural markets of some of these policy measures.

Specifically, we analyse four scenarios. In the first scenario, we increase support payments to farmers cultivating protein-rich crops (soya beans and pulses) by EUR 75 per ha, beginning in the year 2020, raising the level of coupled support given to protein crops up to 2% for all Member States implementing voluntary coupled support payments. In the second scenario, yields for pulses and soya beans are gradually increased relative to the EU's outlook baseline over the period 2020–2030, to reflect the relative impact of productivity increases through increased R&D (Figure 2).

It is assumed that by 2030 pulses and soya bean yields have increased by 75 kg/ha (3%) and 162 kg/ha (5%), respectively, relative to the baseline. This implies an average annual yield growth of 1% for both crops in the outlook period 2020–2030. In the baseline, the average annual yield growth is 0.7% and 0.5 %, respectively, for EU pulses and soya beans. The yield growth rates assumed in this second scenario are based on consultations with market experts. Further information about yield gaps can be found in EIP-AGRI (2014).

The third scenario assumes that the use of palm oil in the production of biodiesel is gradually phased out completely in the period 2020–2030. This is probably an unrealistic assumption as the use of palm-based biodiesel in the EU is likely to decline as a result of RED II significantly, but likely not to zero (EC 2019a). The baseline already foresees a sharp decline in EU palm oil palm-based biodiesel from around 3 million tonnes in 2020 to 0.745 million tonnes in 2030. The 2018 recast Renewable Energy Directive [RED II – Directive (EU) 2018/2001] requires the phasing out of biofuel feedstocks with a high risk of inducing indirect land-use change (ILUC). Palm oil is considered to be a high-risk ILUC feedstock and palm-based biodiesel therefore needs to be certified as 'low ILUC-risk' in order to count towards RED II target of 14 % renewables in the transport sector (Commission Delegated Regulation (EU) 2019/807). In the scenario, unlike in the baseline, we assume that no such certification occurs.

The fourth scenario simply considers the combined effect of the three individual scenarios together. We shall refer to the additional support scenario

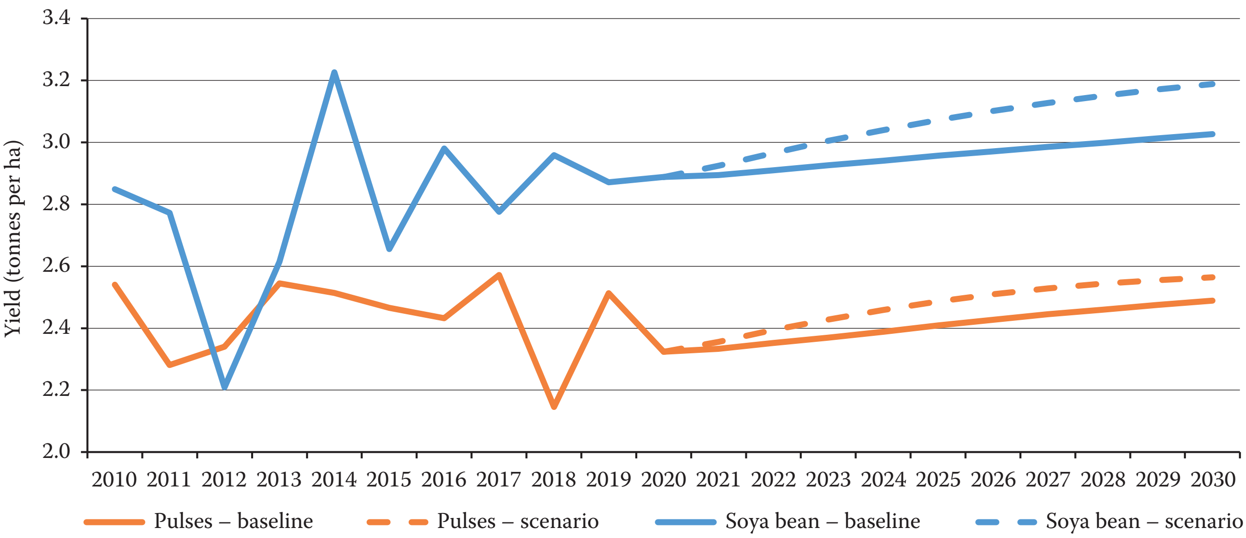

Figure 2. Changes in EU yields for soya beans and pulses compared to the baseline, 2021–2030 (tonnes per ha)

Source: Own calculations based on output from the Aglink-Cosimo model (OECD/FAO 2020)

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Table 1. Scenario descriptions

Scenario	Description	Scenario assumptions
SCEN_SUPP	coupled support scenario (EU production of protein-rich crops receives coupled support)	increase in support payments to soya beans and pulses by EUR 75 per ha, beginning in the year 2020
SCEN_YLD	high yield growth scenario (technological advances lead to relatively large productivity increases of EU protein-rich crops)	soya beans and pulses both experience an annual yield growth of 1% in the period 2020–2030 (compared to 0.5% and 0.7%, respectively, in the baseline)
SCEN_ILUC	no palm oil in biodiesel scenario (use of imported high ILUC risk biofuel feedstocks is phased out)	use of palm oil in EU biodiesel production is gradually phased out in the period 2020–2030
SCEN_COMB	combined scenario	assumptions from the three scenarios above combined

ILUC – indirect land-use change
Source: Own elaboration

as SCEN_SUPP, the yield scenario as SCEN_YLD, the ILUC scenario as SCEN_ILUC and the combined scenario as SCEN_COMB. The scenarios are summarised in Table 1.

RESULTS AND DISCUSSION

Land-use, production and price effects for oilseeds and pulses. In SCEN_COMB the combined effect of the three policy drivers causes the harvested area of pulses and oilseeds to increase by a total of 107 000 ha, relative to the baseline, mainly due to increased yields and coupled payments (Table 2). Considering the effects on pulses first, their harvested area and production increase by 73 000 ha (3.3%) and 353 000 tonnes (6.4%), respectively, in 2030, relative to the baseline. Improved yields (SCEN_YLD) and coupled payments (SCEN_SUPP) both raise the per-hectare crop value, causing the pulse area to increase by 3 000 ha and 71 000 ha, respectively. Although higher support levels lead to a much larger area expansion than higher yields, the yield impact accounts for almost 50% of the increased pulses production. The simple reason for this is that higher yields increase production from the existing area and not just the new area resulting from the policy changes. Coupled support also increases yields but not as much as in SCEN_YLD. The EU has a large degree of self-sufficiency in pulses, and the increased supply pushes down EU market prices (Table 3). Lower domestic prices increase the international competitiveness of EU pulses, so exports go up and imports decline.

For soya beans, the combined effect (SCEN_COMB) is an increase of 28 000 ha (2.1%) in the harvested area and 309 000 tonnes (7.6%) in the amount produced. However, domestic prices only fall marginally in this case as the EU is a major importer of soya beans. The increase in production, therefore, reduces imports by the same amount. As with pulses, the improved yields and additional support raise the per-hectare crop value, leading to an increase in the harvested soya bean area by 19 000 ha and 10 000 ha, respectively. The yield impact (SCEN_YLD) accounts for two-thirds of the increased production, dominating the supply response.

Table 2 indicates that the rapeseed area is not affected much by the higher yields and additional coupled payments to soya beans and pulses. However, the rapeseed area does increase in response to the phasing-out of palm-based biodiesel (SCEN_ILUC), which has some knock-on effects on the EU vegetable oil market. The increased demand for rapeseed oil caused by the lower palm oil imports leads to an increase in rapeseed prices by 1.1% (Table 3), which stimulates the production and increases the harvested area by 11 000 ha.

The increases in the pulses and oilseeds area in the scenarios lead to decreases in the area of other crops. In SCEN_COMB, for example, the wheat area decreases by around 33 200 ha, the coarse grains area decreases by around 54 400 ha and the pasture and fodder area (which does not include permanent pasture) by around 13 000 ha. The net effect is a modest increase of 10 500 ha in the total EU agricultural area. Table S1 in the electronic supplementary material (ESM) summarises the land-use changes in the four scenarios for the main crops in the model; for ESM see the electronic version.

Table 4 elaborates on the changes in vegetable oil uses resulting from the increased production of the crops in Table 2. Domestically sourced vegetable oils increase

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by 55 000 tonnes, with the increased soya bean production accounting for the lion's share (58 000 tonnes). Sunflower oil production from domestic seeds increases marginally by 5 000 tonnes, whereas rapeseed oil from domestic rape declines by 9 000 tonnes. Tables S2–S3 in the ESM (for ESM see the electronic version) sum-

Table 2. Changes in EU area (1 000 ha), production and trade (1 000 tonnes) for oilseeds and pulses, compared to the baseline in 2030

Scenario	Pulses	Rapeseed	Soya bean	Sunflower	Total
SCEN_COMB					
Imports	–122	92	–318	–5	–353
Exports	109	–14	0	3	98
Production	353	25	309	4	691
Area	73	4	28	2	107
SCEN_SUPP					
Imports	–60	9	–27	3	–75
Exports	45	–1	0	–2	42
Production	161	–17	31	–9	166
Area	71	–6	10	–4	71
SCEN_YLD					
Imports	–65	1	–261	1	–324
Exports	50	0	0	–1	49
Production	174	–5	278	–3	444
Area	3	–2	19	–1	19
SCEN_ILUC					
Imports	2	81	–28	–9	46
Exports	–1	–13	0	6	–8
Production	–3	48	–2	17	60
Area	–1	11	–1	8	17

For scenario descriptions, see Table 1
Source: Own calculations based on output from the Aglink-Cosimo model (OECD/FAO 2020)

Table 3. Change in EU producer prices compared to the baseline in 2030 (%)

	SCEN_COMB	SCEN_SUPP	SCEN_YLD	SCEN_ILUC
Crop markets				
Pulses	–4.4	–2.0	–2.2	0.0
Soybean	–0.2	0.0	–0.2	0.0
Sunflower seed	–0.2	0.1	0.0	–0.3
Rapeseed	1.1	0.1	0.0	1.0
Meal markets				
Soybean meal	0.0	0.0	0.0	0.0
Sunflower meal	0.0	0.0	0.0	0.0
Rapeseed meal	–0.4	0.0	0.0	–0.5
Oil markets				
Soybean oil	0.4	0.0	0.0	0.4
Sunflower oil	0.2	0.0	0.0	0.2
Rapeseed oil	4.1	0.0	0.0	4.0

For scenario descriptions, see Table 1
Source: Own calculations based on output from the Aglink-Cosimo model (OECD/FAO 2020)

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Table 4. Change in vegetable oil uses by source in SCEN_COMB (1 000 tonnes; EU 2030)

Source	Biodiesel	Food	Exports	Total
Oil (from EU seed/beans production)	135	–59	–20	55
Oil (from seed/beans imported)	79	–45	–42	–11
Imported rapeseed, soya bean, sunflower oil	158	44	0	205
Imported palm oil	–745	43	0	–702
Total change	–373	–17	–63	–453

For scenario descriptions, see Table 1

Source: Own calculations based on output from the Aglink-Cosimo model (OECD/FAO 2020)

marises the scenario impacts per crop for SCEN_COMB and SCEN_ILUC, respectively. The relatively modest increase in domestically sourced vegetable oils when moving away from palm-based biodiesel is due to the dynamic, open economy of the vegetable oil market within the EU. The removal of 0.745 million tonnes of palm oil from the biodiesel feedstock by 2030 raises the demand for rapeseed, and soya bean oil, increasing the vegetable oil price and thereby the incentive of crushing domestically grown crops. But the higher price of domestically produced oil reduces exports and domestic use of food oil originating from EU rapeseed, soya bean and sunflower production. At the same time, imported oil becomes more competitive and imports increase. This means that the 131 000 tonnes increase in the use of vegetable oil crushed from EU seed/bean production in biofuel production is in part coming from lower consumption of domestically sourced food oils and exports.

Palm oil consumption in the EU declines by less than the 0.745 million tonnes (a reduction in palm oil imports used in the biodiesel sector due to the increase in food use of imported palm oil). Imports of rapeseed, soya bean and sunflower oil used in food increase. Still, the reduction in domestically produced vegetable oil used for food dominates these increases. Hence, the net result is a decrease in the use of vegetable oil in food in the EU. As the bottom line in Table 4 shows, the total effect is a modest 453 000 tonnes reduction in demand for vegetable oil. The combined effect of the three policies is marginal increase in domestic availability of biodiesel resulting from an increase in imported and a decrease in exported biodiesel which more than compensates for the lower production (not shown in Table 4). The main impact on biodiesel consumption is in SCEN_ILUC.

Demand effects on pulses and protein meals. In SCEN_COMB the use of pulses as animal feed increases by 119 000 tonnes (3.6%) in the EU, whereas only a small increase in food consumption and other uses (7 000 tonnes) is projected by 2030. Higher yields and additional coupled support raise the feed use of pulses of EU origin from 92% to 94 %, increasing self-sufficiency marginally. As shown in Table 5, higher yields and additional coupled payment for soya beans, combined with the phasing-out of biofuel feedstock with a high risk of ILUC (SCEN_COMB), increases the use of vegetable protein meals in the EU by a modest 0.1% or 45 000 tonnes (57 000–12 000 tonnes). The larger supply of domestically sourced vegetable oils also improves protein self-sufficiency through an increase in EU-sourced protein meals by 235 000 tonnes in 2030. Most of this comes from domestically grown soya bean meals (213 000 tonnes). Consumption of meal from imported oilseeds, on the other hand, declines by 175 000 tonnes due to higher domestic production resulting from additional support and higher yields leading to a reduction

Table 5. Changes in EU vegetable protein meals use by source, in 2030 compared to the baseline in SCEN_COMB (1 000 tonnes)

Source	Rapeseed	Soya bean	Sunflower	Total
Meal (from EU seed/beans production)	22	213	–1	235
Meal (from seed/beans imported)	51	–223	–3	–175
Imported rapeseed, soya bean, sunflower meal	12	–10	6	–16
Exported rapeseed, soya bean, sunflower meal	12	0	0	12
Total change	74	–19	2	57

For scenario descriptions, see Table 1

Source: Own calculations based on output from the Aglink-Cosimo model (OECD/FAO 2020)

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in imported soya beans. Table S5 in the ESM (for ESM see the electronic version) summarises the meal market impacts in each of the scenarios.

Rapeseed meal consumption increases in SCEN_ILUC as a result of higher domestic production and imports of rapeseed. The latter is slightly higher than the former, so the rapeseed meal self-sufficiency rate declines marginally. The increased production of protein meals and pulses reduces feed prices (Table 3), stimulating a slight increase in meat and milk production (<1%) and a reduction in the amount of wheat, maise, and other coarse grains being fed to livestock.

Discussion. What is apparent from the results is that providing coupled support of EUR 75 per ha of soya beans and pulses, which is equivalent to an extra-budgetary outlay of EUR 273 million in 2030, is a fairly expensive way of increasing protein self-sufficiency. The coupled support amounts to EUR 102 million for soya beans, which corresponds to almost EUR 10 400 per additional ha grown or EUR 3 300 per additional tonne produced. Another way of putting it is that EUR 102 million in coupled support to soya bean production increases the value of production (i.e. change in production multiplied by the producer price) by EUR 14.3 million. The coupled support amounts to EUR 171 million for pulses, corresponding to approximately EUR 2 400 per additional ha grown or EUR 1 063 per additional tonne produced. In this case, the EUR 171 million in coupled support increases the value of production by EUR 24.5 million. The question is whether the environmental impacts from the increased cultivation of these crops and the reduction in imports produces benefits that are high enough to justify such a large redistribution from taxpayers to producers. Another way to reduce the dependency on imported proteins is to focus on increasing yields of soya and pulses through R&D investments.

Our results show that an annual yields growth of 1% in the period 2020–2030 will have a much larger effect on EU protein production than additional coupled payments of EUR 75 per ha. The question is, can such progress be achieved, and how much will it cost to achieve it? There is a large literature on the connection between agricultural R&D, technology, and productivity (Piesse and Thirtle 2010; Alston 2018). This literature typically studies the relationship between total R&D expenditure and agricultural productivity rather than the relationship between R&D expenditure on specific crops and their yields, i.e. a partial productivity measure.

In order to come up with a back-of-the-envelope estimate of the expenditure required to increase pulses and soya bean yields by 3% and 5%, respectively, relative to the baseline, we can use the elasticity of productivity with respect to a change in the knowledge stock reported in Andersen (2015) of 0.491. This elasticity implies an increase of around 6% and 10% in the R&D expenditure on pulses and soya beans, respectively, in the whole outlook period. The General Services Support Estimate (GSSE) for the EU in 2019 was EUR 10.443 billion (OECD 2021). This includes public expenditures in the agricultural sector but also non-R&D expenditures on infrastructure. The share of agricultural knowledge and innovation system in the EU-28 GSSE is 57% for 2019 or EUR 5.953 billion. Assuming that R&D spending is proportional to land-use, this implies R&D expenditure of EUR 50 million and EUR 36.4 million on pulses and soya beans, respectively. Increases of 6% and 10% amount to a total of EUR 6.8 million in additional expenditure per year to reach the protein yield target for 2030. If we assume that private R&D expenditure is equal to public expenditure (since GSSE only includes public expenditure) and that the EU R&D elasticity is only one-fifth of the US value, an almost ten times higher additional expenditure (EUR 67.7 million per year) would be needed in order to achieve the required yield increases. This is still only a quarter, though, of the additional budgetary outlay of EUR 273 million in SCEN_SUPP.

CONCLUSION

This paper contributes to the literature on protein self-sufficiency in the EU, with an analysis of different options for increasing protein crop production and their likely impacts on agricultural markets. We find that promoting higher yields of protein-rich crops through R&D has the potential to increase domestically produced plant-based protein feed substantially in the medium to long-term, thereby partly reducing the EU's protein deficit. Increasing coupled support for soya beans and pulses, on the other hand, only contributes to a modest increase in domestic production of protein crops. A complete phasing out of palm-based biodiesel has a limited impact on protein meal produced from domestically sourced oilseeds, given the many feedstock options for biodiesel production. In fact, it specifically leads to an increase in the EU rapeseed and sunflower area, but also to additional rapeseed imports. Last but not least, it is important to highlight that the agricultural area devoted to the production of legumes actually decreases in this scenario due to area competition with rapeseed production. Therefore, a complete passing out of palm-based biodiesel will not add to the biodiversity of the agricultural landscape.

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The results presented here are obviously dependent on the assumptions used in the analysis. Further research should focus on the main uncertainties underlying these and identifying the economically feasible yield potentials by crop and region.

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