

ASSESSING FEASIBILITY OF SOYBEAN SUBSTITUTION WITH ALTERNATIVE LEGUMINOUS CROPS FOR SOUTH EAST EUROPEAN COUNTRIES

Spyros Niavis¹, Christina Kleisiari², Leonidas-Sotirios Kyrgiakos² and George Vlontzos²

¹Department of Planning and Regional Development, University of Thessaly, Greece

²Department of Agriculture, Crop Production and Rural Environment, University of Thessaly, Greece

spniavis@uth.gr, chkleisiari@uth.gr, lkyrgiakos@uth.gr, gvlontzos@uth.gr

ABSTRACT

It is a fact that there is a high trade deficit (around 70%) in Europe with regards to protein crops. This is a significant reason for the EU to implement policies aiming at reducing the dependence of imported materials with high protein content for animal feed use. Due to their competitive prices, soybeans imports from the USA and China are particularly attractive choices for European importers and feed users. A very promising policy approach to tackle this phenomenon seems to be the implementation of production protocols for the legumes cultivation, based on the sustainability and use of economically and environmentally friendly practices in accordance with European directives. Following this line of reasoning and taking into account all the existing constraints in Southern Europe for achieving sustainability, this work explores a time period 2007-2016 evaluating four main high protein crops so as to evaluate the feasibility of a successful soybean substitution. *Pisum sativum subsp. arvense L.* and *Lupinus albus* are the species primarily examined in this research, in an attempt to replace partially or completely the soybean meal in the dairy cow diet. In addition, this research evaluates the impact of these legumes on the environment through crop rotation, which has significant implications for environmental indicators improvement. Considering the actions presented in the second pillar of the EU Common Agricultural Policy, an attempt is made to replace the imported soybeans while preserving national natural resources. EU policy should support the cultivation of such local high protein crops in order to achieve Sustainable Development Goals.

Keywords: livestock feed, soybeans, legumes, *Pisum sativum*, *Lupinus albus*, South Europe

1. INTRODUCTION

From 2012 to 2019, soybean production has been raised from 250 to 350 million tones with USA, Brazil and Argentina holding the leading positions, producing almost 75% of overall production (USDA, 2019). On the other hand, China and European Union are the primary importers of soy, using soybeans and soymeal mainly as feed. Dominance of soybeans in animal industry has been established due to its high protein concentration over its volume. European Union is highly dependent in USA soybeans imports, so as to cover animal nutritional needs.

Aiming to reduce economic and environmental cost of imported amounts of soybeans, EU seek ways, through new CAP after 2020, to boost protein crop cultivation. It has been stated that European soybeans production can cover only 5% of total needs of soybean in Europe (European Commission, 2018). Combining the above mentioned with the fact that EU has one of the largest meat consumption per capita, alternative solutions should be implemented. Alternative leguminous crops can be a

feasible solution, in order to achieve continental sustainability under climate change index, where minimum resources should outcome qualitative products that meet quantity needs.

Alternative leguminous crops present appropriate characteristics for animal industry use, in order to substitute soybeans crop which has high needs of chemical inputs, resulting in environmental damage (FAO, 2009). There is a growing interest in use of legume- based green manure stemming mainly from the rising cost of synthetic inputs and concerns about the environmental performance of agriculture. For this reason, high protein crops can be used as a part of a crop rotation resulting in improved soil properties, and nitrogen supply for the following crop. It has been shown that this type of manure can increase soil nitrogen availability, as atmospheric nitrogen is absorbed by the legumes, and subsequently incorporated into manure by nitrogen assimilation (Baddeley, 2017). Using minimum amount of fertilizers leads to great decrease of greenhouse gases, due to the high needs of energy for their manufacture. Additionally, local legumes production contributes to GHG emissions decrease due to minimum need for transportation in comparison with the imported quantities. Another crucial point, is that less water is needed during grain filling, a significant characteristic for areas that are facing elongated periods of drought.

Literature review of Palhares & Pezzopane (2015) concludes that leguminous crops can be an alternative source of feed for the European Union countries, underlying the significance of support measures and appropriate plant breeding programs. Main restrictions for adaptation of alternative leguminous crops are that 1) they present lower levels of proteins in comparison with soybeans 2) their cultivation is not very common and for this reason farmers are afraid to adopt a newly introduced crop, 3) there are not enough quantities to cover EU animal industry needs and permit their further expansion. Leguminous crops not only do not affect the quality and the quantity of milk production, but also increase animal welfare by decreasing urea levels in their blood (Tufarelli et al., 2012)

In the light of these observations, this document highlights the market situation and market dynamics of Southern European countries in the production of high protein vegetable sources for animal feed. At the outset, the development of the production of the main protein crops is outlined, including mainly soybean, lupine, green beans and green peas cultivation. Furthermore, data such as annual production volumes, yield and value added for each of these crops are recorded and analyzed. Secondly, country-level data are analyzed to better outline European soybean and other legumes production. Through this document, an attempt to outline the mix of protein crops grown in South Europe is made, while at the same time we highlight the most efficient crop in terms of land use and production value. This paper seeks to address the following research questions:

- Are there any changes regarding soybean production for the last decade in SE European countries?
- Does soybean production present high efficiency level in land use and economic profit index?

2. METHODOLOGY

Data has been collected from Food and Agriculture Organisation (FAO) and Eurostat referring to the 2007-2016 period in order to investigate alterations of protein crop mix in South-European countries. Four main leguminous crops have been selected for this paper due to their high protein concentration, environmental and economic significance. The countries taken under consideration are presented in Table 1. Analysis is conducted by utilising basic statistical measures as well as correlation analysis, as appropriate.

Table 1. Description of the key data of the paper

Crops	Total Output (tonnes)	Yield (Hg/ha)	Total Value	CO ₂ and N ₂ O direct emissions
Green beans	X	X	X	
Green peas	X	X	X	
Lupinus	X	X	X	

Soybeans	X	X	X	X
Countries	Albania, Bosnia, Bulgaria, Croatia, Cyprus, France, Greece, Italy, Malta, Montenegro, North Macedonia, Portugal, Romania, Serbia, Slovenia, Spain			
Years	2007-2016			

3. RESULTS

3.1 Investigating the mix of high protein crops in South-East Europe

Annual production of selected crops from South-East Europe countries is depicted in the following figure (Figure 1). It can be easily seen that protein crop production has almost been doubled within the last 10 years. Although, production of high protein crops has not been increased accordingly. Green peas and lupins have remained stable during the whole reference period 2007-2016, while there is a slight decrease of green beans. Soybeans production remains at same levels between 2007-2009, a temporary increase for the next year and then decreasing in the initial levels of 2009. However, 2012 seems to be a very crucial year from which, EU soybeans production has been increased 2.5 times.

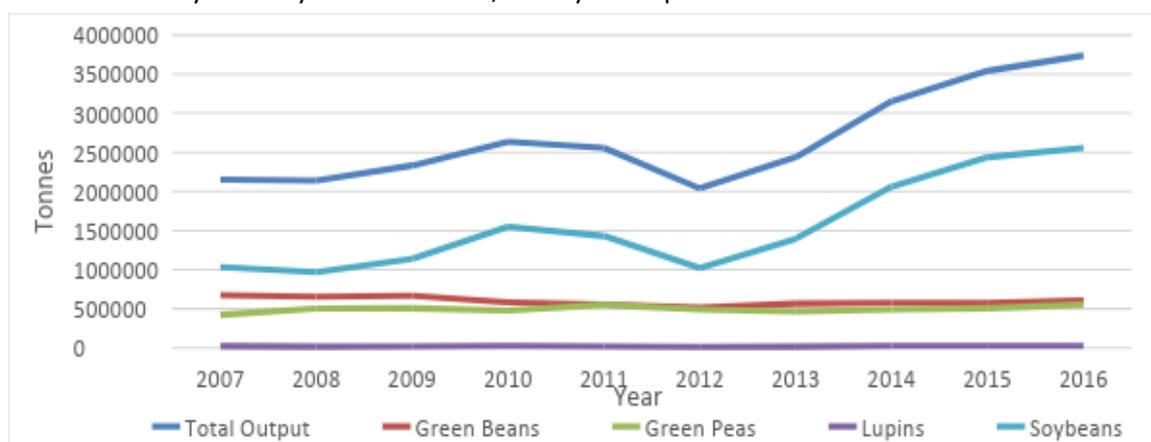


Figure 1. High protein crops production in SE Europe (2007-2016), Source: FAO, 2019

After 2012 there is an apparent dominance of soybean over the other leguminous crops, resulting in a completely different protein crop proportion mix. From 2007 to 2016, green beans ratio has been shrunk from 31.3% to 16.2% accordingly (Figure 2). A smaller decrease is being depicted for green peas and lupines for the same years. However, soybean output has been increased from 48% to 68.4%, meaning that there is a remarkable shift to soybean production from SE Europe countries.

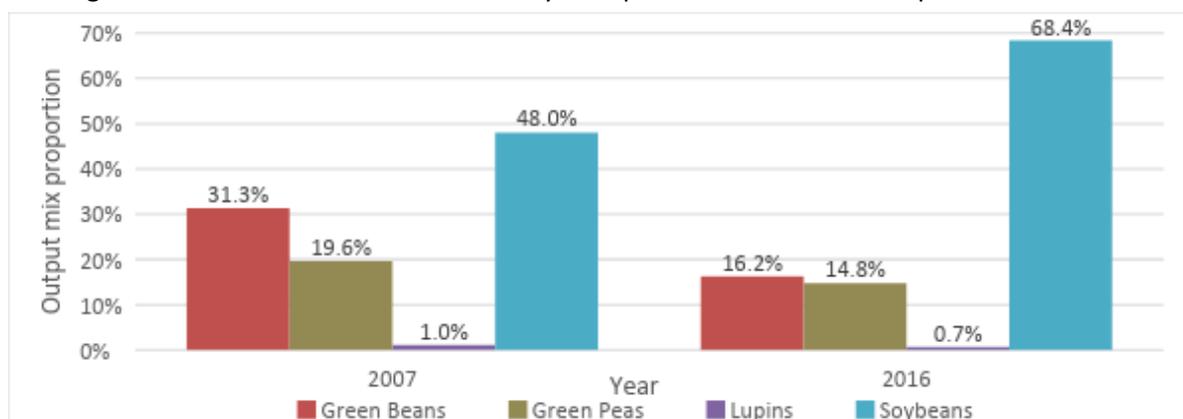


Figure 2. Proportion of the four high protein crops in the total output mix of SE Europe (2007-2016), Source: FAO, 2019; Authors elaboration

3.2 Investigating the yield and value of the high protein crops

In the following figure the average yield (hg/ha) and the value (International \$/Kg) of the four high protein crops are presented for the countries of SE Europe (Figure 3). Green beans appear with the highest productivity level among the four leguminous crops, scoring around 1.3 million hectograms per hectare, followed by lupines producing about 1.1 million hectograms per hectare. Soybeans present 65% less yield than lupines, while green peas production levels remain very low at about 100 thousand hg/ha. Assessing the economic values of protein crops per kilo, it is being revealed that green beans return about 0.33\$/kg. Green peas are the second ones, with an average price of 0.31\$/kg followed by soybeans with 0.28\$/kg. Lupines have the lowest price of 0.16\$/kg. From the above mentioned results, it seems that excessive soybean production has led SE European countries to loose both in productivity and income, whilst they could have focused in specialization of green beans production.

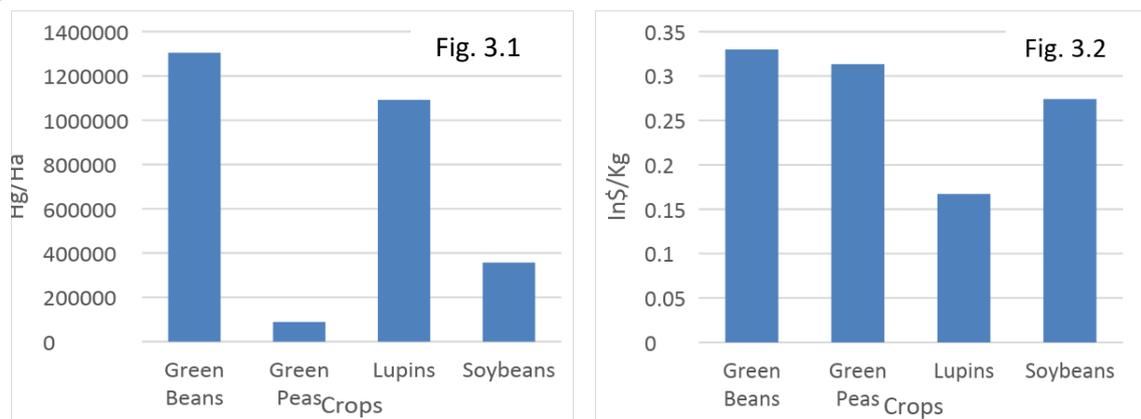


Figure 3. Yield (Fig. 3.1) and value (Fig. 3.2) of the four high protein crops in SE Europe (2016), Source: FAO 2019; Authors elaboration

3.3 Investigating the individual records of countries in soybean production and its relationship with the performance of the agricultural sector

Table 2 gives an insight of soybean production in SE European. More precisely, production, proportion of soybean in crop mix, yield and changes in soybeans in the period 2006-2017 are presented. Italy, Serbia and France have achieved the highest production while on the other hand highest dependence in soybean production is depicted from Croatia, Bosnia and Serbia. In the timeline of 2006-2017 only Albania has a reducing rate of soybean production. Greece, Bulgaria and Slovenia present the highest increase. Greatest yields have been achieved by Italy, Croatia and Spain. Considering the environmental impact of soybean production, CO₂ and N₂O per product have been assessed. Greece and Spain were able to produce soybeans with the least of emitted amount of greenhouse gases.

Table 2. Basic figures of soybeans production in the countries of SE Europe, Source: FAO, 2019; Eurostat, 2019; Authors elaboration

	Soybean Production (tonnes)	Soybean Proportion	Soybean Change	Soybean Yield (HG/HA)	CO ₂ /Product	N ₂ O/Product
Italy	1,081,340	80%	37%	37,539	0.0577	0.0019
Serbia	576,446	89%	11%	31,610	0.0605	0.0020
France	338,864	52%	99%	24,849	0.0655	0.0021
Romania	263,380	80%	16%	21,045	0.0697	0.0022
Croatia	244,075	97%	8%	31,047	0.0609	0.0020
Bosnia	18,662	90%	11%	26,576	0.0640	0.0021
Bulgaria	18,301	60%	6870%	12,923	0.0869	0.0028

Slovenia	7,387	68%	474%	29,955	0.0615	0.0020
Greece	4,000	5%	31417%	25,806	0.0567	0.0018
Spain	2,869	1%	208%	28,830	0.0452	0.0014
Albania	664	4%	-11%	25,152	0.0652	0.0015

Table 2 illustrates the significant differences between countries' efficiency in soybeans cultivation. It seems, therefore, that countries which do not have the capacity to make effective use of their natural resources are forced to cultivate exclusively soybeans and thus suffer from a lack of competitiveness. This led to the need to conduct a series of correlational analyses to assess the relationship between soybean production and the efficiency of the country's agricultural sectors (Table 3). This analysis correlates the level of country specification in soybean production with four different variables that represent different dimensions of efficiency related to soybean production and the agricultural sector in general. The first variable is defined as the total yield of cultivated protein crops and the results show that soybean specialization is capable of leading to loss of yield, as there is an inversely proportional relationship between soybean specialty and high protein crop efficiency. The second variable depicts the output value per unit of output and, as in the first variable, the relationship to soybean specificity is inverted, a fact that is shown by the negative and statistically significant correlation coefficient. From this variable, it appears that countries that specialize in soybeans show a decline in generated value. The third variable, this of CO₂ emission per soybean production unit, is not statistically significant, a fact which proves that the increase in soybean specialization does not have a positive impact on the environmental efficiency of the crop. The fourth variable, expressing soybean yield, is not statistically significant too and therefore the conclusion is that there is no linear relationship between soybean specification and soybean yield.

Table 3. Results of the correlation analysis among the level of specialisation and effectiveness of agricultural sectors in SE Europe

Variable	Total yield	Generated value	CO ₂ Emissions	Soybeans yield
Spearman Coefficient	-0.502*	-0.849***	-0.125	0.404

*** Statistical significance (two-tailed) at the 0.01 level.

** Statistical significance (two-tailed) at the 0.05 level

* Statistical significance (two-tailed) at the 0.10 level

4. CONCLUSIONS

In this paper, evolution of high protein crops during the period 2007-2016, in South East Europe is depicted. An overall increased protein production is obvious, resulting in less dependence of soybean imports. Moreover, soybeans production has been increased 2.5 times from 2012-2016, meaning that soybean is a main importance high protein crop for SE Europe countries. On the other hand, this research reveals that higher yield and prices can be achieved from green beans. Combining this with the above-mentioned increase of soybeans, it can be stated that green beans should earn a largest proportion of high protein mix, minimizing soybean imports and increasing net values. In the second part of this paper, specialization in soybean production, seems that it does not affect production and yield, whilst there are no significant differences in the overall efficiency.

Taking all the above mentioned into consideration, significant differences are observed between the EU strategy for high protein crops cultivation and final outcomes. Although EU states that soybeans imports should be minimized by focusing on alternative leguminous crops for increasing self-sufficiency and environmental protection, data shows a clear dominance of soybeans in SE Europe. For many years, EU has implemented a series of tools in order to promote production of certain crops, covering people needs at the time given. It still remains a goal for the EU to support alternative leguminous crops under the upcoming CAP (2020-2024), in order to achieve Sustainable Development Goals.

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