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Faculty of Landscape Architecture, Horticulture and Crop Production Science

Managing uncertainties and development of grain legumes in Sweden

Hantering av osäkerhetsfaktorer samt utveckling av baljväxter i Sverige

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Abstract

Grain legumes have proven in many studies to have beneficial effects on both the agricultural system and for human health. Agronomic and environmental benefits with the lower use of synthetic nitrogen, improvement of soil health, and contribution towards a more diverse agricultural system has alongside with the high nutritional value proven the grain legumes importance of presence. Inspite of all these benefits, the presence of grain legumes for human consumption in the cropping systems in Sweden is relatively small. The purpose of this study was therefore to get a better understanding of why grain legumes are not more commonly cultivated and consumed in Sweden, and identify ways to overcome the challenges. Through semi-structured interviews with actors working in the cultivation and trading of pea and lentil for human consumption in Sweden, the experiences for managing grain legume yield variability and factors causing uncertainty was explored, as well as the future vision for developing and increasing yellow dry pea and lentil cultivation and consumption. The main factors causing variability and uncertainty among the farmers and traders in this study were: consumer demand, economic incentives and subsidies, variable weather conditions, few available varieties suitable for human consumption and cultivation in Sweden, difficulty in post-harvest processing and limited areas of use. With further research of pea and lentil varieties suitable for human consumption in Sweden, public subsidies for domestic cultivation of grain legumes, and more actors working with processing and creating new products with grain legumes, the factors causing uncertainty and variability would decline and cultivation area and consumption of peas and lentils for human consumption in Sweden could increase.

Sammanfattning

Baljväxter har i flera studier bevisats ha fördelaktiga effekter för både miljön och hälsan. Genom lägre användning av konstgödsel och ökad markhälsa bidrar baljväxter till mindre utsläpp av växthusgaser och har med dess goda näringsvärde bevisat sin viktiga roll i både jordbruket och livsmedelssystemet. Men ändå så odlas baljväxter för humankonsumtion endast på en relativt liten odlingsareal. Denna studie har utforskat

varför det inte odlas och konsumeras mer baljväxter i Sverige. Genom semi-strukturerade intervjuer med aktörer som arbetar med odling och handel av gula ärter och linser för humankonsumtion har orsakerna till osäkerhet och variation utforskats samt aktörernas framtidsvision för hur odlingsytan och konsumtionen av svenskodlade gula ärter och linser kan öka. De främsta faktorerna som orsakat osäkerhet och variation för odlarna och uppköparna i denna studie var: efterfrågan från konsument, ekonomiska drivkrafter och tillgång till bidrag, väder, tillgången till sorter anpassade för humankonsumtion och svenska förhållanden, efterskördhanteringen samt användningsområden. Med fortsatt forskning om sortutbud och odlingsmetoder, ekonomiska bidrag för baljväxtodling, fler aktörer som arbetar med förädling, hantering och skapande av nya produkter och användningsområden med baljväxter, så kan faktorerna som orsakar osäkerhet och variation minska och odlingsarealen och konsumtionen av gula ärter och linser för humankonsumtion i Sverige kan öka.

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Introduction

Agriculture is commonly seen as both a reason and a part of the solution for many of the known challenges that we face today, including climate change, food security and biodiversity loss. Together with forestry and other land use it provides the human population with food, fiber, livelihood, and vital ecosystem services, but, it is also contributing with approximately 25 percent of the anthropogenic greenhouse gas-emissions (Smith et al, 2014), mainly from deforestation and emissions from livestock and soil and nutrient management. Agriculture affects biodiversity, ground water levels and purity, soil health, food security levels etc, and is therefore essential to take measures for reducing its negative impact on the environment. Diversification in the agricultural systems to secure food security today and in the future while reducing the negative impact that agriculture has on the environment seems today to be an equally big challenge as well as an obvious solution (Lin B., 2011; Meynard et al, 2018; FAO, 2019; FAO, 2016). Increasing biodiversity and resilience while maintaining high yields to feed the human population is a challenge that require action from several sectors in society, including research and governmental regulations and support. Changes in both the supply-side, with agricultural practices as well as land management and processing practices, and the demand-side, the consumer demand, awareness and consumption, is essential for mitigating greenhouse gas emissions from agriculture and support the development towards a healthy and well-being population and planet (Smith et al, 2014).

The emissions from manufacturing synthetic fertilizers is one of the main contributing factors for the high greenhouse gas emissions identified from agriculture (Smith et al, 2014). Synthetic fertilizers do increase the yield of most cultivated crops, compared to non-fertilized crops, but also negatively affect the efficiency of the natural cycle of nitrogen in the environment (Raven et al, 2005). It can, in areas where it is heavily used, pollute drinking water supplies (Raven et al, 2005). Increasing the cultivation of crops that are less dependent on synthetic fertilizers would reduce its use while increasing soil fertility. Legumes are such crops which can fix atmospheric nitrogen and reduce the need for artificial fertilization. Their ability to form a symbiosis with Rhizobia-bacteria that can convert atmospheric nitrogen into plant-available form has been known for centuries (Raven et al, 2005).

Grain legumes, which are legumes cultivated for their edible seeds, harvested mature and dried before sale also have a high nutritional value as it is a good source of protein, slow release carbohydrates, minerals and vitamins (Tharanathan, 2003).

A French case study (Magrini et al, 2016) explored the reasons for why grain legumes are rarely present in cropping systems despite their environmental and nutritional benefits. Their study explains the reason to be a situation of technological lock-in because of the co-evolution of crop system, based on agrochemical paradigm, public policies, and market dynamics that has promoted cereals over grain legumes. Interrelated factors such as breeding selection, public subsidies, and food systems, are specified as factors that have encouraged cultivation of cereals over grain legumes. According to the study, grain legumes have also, in general, been considered feed for animals instead of food for humans.

In Sweden legumes are cultivated on approximately 2 per cent of the agricultural land i.e 56,500 hectares (Olsson, 2018) and most of the harvest goes to animal feed (personal communication with The Swedish Board of Agriculture, 2019). If the meat consumption in Sweden would be reduced by 50 per cent and replaced with domestically grown grain legumes, the climate impact of the average Swedish diet could be reduced by 20 per cent too and the land use would be reduced by 23 per cent (Röös et al, 2018).

Grain legume cultivation has many benefits for both the environment and the human health, but it is still relatively rare to cultivate grain legumes for human consumption. This study will investigate the first part of the value chain of grain legumes in Sweden, cultivation and trading, to get a better understanding of what factors affect variability and uncertainty as well as exploring how it can develop.

Aim

This thesis examines the experience over time from important actors for cultivation and trading of grain legumes for human consumption in Sweden. The following research questions were set out to address the overall aim of this study:

- What are the main success factors and uncertainties for cultivating and trading with pea (*Pisum sativum)* and lentil (*Lens culinaris)* today in Sweden, and how has it evolved in time and with experience?
- What is the future vision for pea and lentil in Sweden?

This study focused on one traditional legume, defined as a grain legume that has been cultivated in Sweden for a long time and that is also relatively well-known in the Swedish kitchen, and a "new" grain legume, defined as a crop that is less cultivated in Sweden and relatively unknown in the Swedish kitchen, mainly considered as a niche-product today. The traditional grain legume in this thesis is chosen to be yellow dry pea and the "new" grain legume is lentil. The number of interviews were limited due to limited time and availability.

Background

Legumes belong to the plant family *Fabaceae* which consist of approximately 18 000 described species (Raven et al, 2005). They are found all over the world and in different kinds of climate zones. Grain legumes are legumes harvested at mature, dry stage and the seeds are used for both food and feed, for example peas (*Pisum sativum)*, beans (*Phaseolus vulgaris)*, sweet lupins (*Lupinus angustifolius)*, chickpeas (*Cicer arientinum*) and lentils (*Lens culinaris*). They are cultivated for their high nutritional value, relatively cheap price (compared to other protein sources) and for their agricultural benefits such as the ability to fix their own nitrogen and their contribution to a more diverse agricultural system. In Sweden, about one hundred wild living species have been found that belong to *Fabaceae* (Jordbruksverket,1999). In Swedish agriculture, peas and faba beans, *Vicia faba,* are the most common among the grain legumes, followed by beans, *Phaleous*

vulgaris (Olsson, 2018). Other grain legumes cultivated in Sweden but in less area are sweet lupin and lentil.

DiverIMPACTS

This study is part of a DiverIMPACTS Swedish case study. DiverIMPACTS is a multi-actor European project bringing together scientists, farmers, farmers' organisations, associations, industries and businesses from 11 European countries to collaborate for the promotion of crop diversification (https://www.diverimpacts.net/) in Europe. 25 concrete innovation projects (case studies) are at the core of this project. One of the DiverIMPACTS case-study is taking place in Sweden, led by Hushållningssällskapet, Skåne in collaboration with SLU's researchers in Alnarp. The main objective of the Swedish case study is to increase the production and human consumption of locally produced legumes (e.g. lupine, lentils, peas, beans) in Sweden in order to decrease farmers' reliance on external inputs (such as synthetic fertilisers and pesticides), and their vulnerability to external factors (trade, policies, climate change, etc.) while promoting farmland biodiversity. A main challenge is also to contribute to healthier food systems relying more on tasty products made with plant proteins, less transportation and more direct connections between producers and consumers.

Benefits for the agricultural system with legumes

Nitrogen fixation

Legumes have the ability to create a symbiosis with Rhizobia- bacteria for nitrogen fixation (Raven et al, 2005). The two most common nitrogen fixing bacteria are *Rhizobium* and *Bradyrhizobium.* The bacteria colonize the plant's root system when the plants are still seedlings, and tumorlike growths known as nodules are formed. Those nodules house the bacteria and provide it with energy derived from the plant through photosynthesis. In turn, the bacteria convert nitrogen from the air into ammonia which is a nitrogen form that is accessible for plants. The enzyme that catalyzes the fixation is called nitrogenase. Rhizobia- bacteria is found all over the world but if legumes are recently added to the crop rotation inoculation might be necessary. When inoculated, the bacteria colonies will survive for several years and no additional inoculation should be

necessary. The amount of nitrogen converted from the atmosphere and available for plants through this symbiosis can vary with species, type of soil, temperature, rate of photosynthesis, pH, amount of accessible nitrogen in the soil, availability of water and plant nutrients, and mechanical practice (Jordbruksverket, 1999). The need for additional synthetic nitrogen fertilizer is therefore reduced.

Break crop- effect and Soil structure

Another benefit of adding legumes to the crop rotation is the break crop effect. Legumes and cereals belong to different plant families and therefore they have different susceptibility to plant diseases, pests and ability to compete against weeds. Adding a legume in the crop rotation can improve disease-control, reduce the abundance of pathogens and weed, and also improve soil structure including improved nitrogen availability (Kirkegaard et al, 2007). In the study by Kirkeggards et al (2007) legumes can increase the yield of the subsequent or intercropping crop when cultivated in the same field, compared with cereal monocultures.

Diversification and resilience

In *Biology of Plants* (Raven et al, 2005) the process of the human being's selection for particular varieties of plants that has desirable trait has led to the dependence of the humans to cultivate the plant as well as the humans' dependence of the plant. Modern agriculture is highly specialized with three cereal crops (rice, maize and wheat) representing more than 50 per cent of plant-based food intake (IPES-Food, 2016). Uniformity and narrow genetic diversity have led to increased yield but can cause high losses in crop production due to the higher vulnerability towards new disease and pests attacks (Raven et al, 2005). An increased crop diversification can improve resilience by creating a greater ability to suppress pest outbreaks and pathogen transmission, as well as working as a buffer in crop production towards the effects of climate variability and extreme events (Lin B, 2011)

Swedish legumes production

The Swedish Board of Agriculture is responsible for the agricultural statistics in Sweden. In their latest report from 2018 (Olsson) the total agricultural area was 3,000,100 hectares. 85 per cent was arable land and the rest was pasture. Legumes were cultivated on 56,500 hectares, which is approximately 2 per cent of the arable land. The cultivation areal of legumes has increased since 2000 but compared to the years 2016 and 2017 the areal for 2018 was less, see figure 1. In the statistics from The Swedish Board of Agriculture (Olsson, 2018) the category legumes include three separate groups: a) peas, field beans, sweet lupin, vetch, chickpea and other beans (grain legumes harvested at mature stage), b) green peas and c) brown beans. Group “a)” account for approximately 93 per cent of the areal of legumes and the balance between the two main crops (pea and field bean) in this group have varied in time. In 2005 peas (dry peas) accounted for 78 percent and field beans 21 per cent, in 2018 peas (dry peas) accounted for 43 per cent and field beans 56 per cent. The remaining 1 per cent are the other legumes that are included in the category “peas, field beans etc” as mentioned earlier. The statistics does not differentiate if the crops are for human consumption or animal feed but in the case of faba beans, most of it is used for animal feed (personal communication with The Swedish Board of Agriculture, 2019).

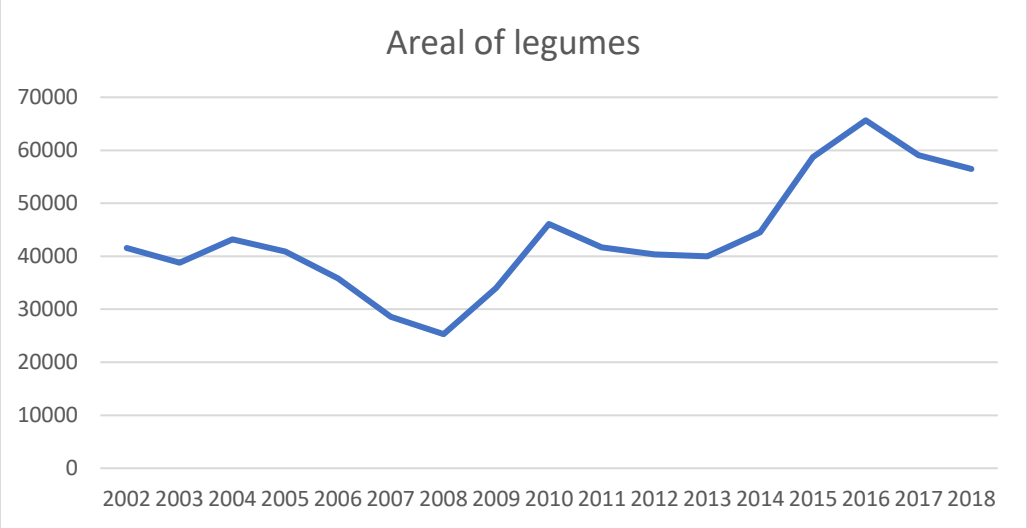

Figure 1; Total area (in ha) cultivated with legumes in Sweden (Olsson, 2015; Persson, 2007; Persson, 2010)

Subsidies for legume cultivation

In the European Union's Common Agricultural Policy (CAP) requirements were introduced in 2013 for introducing ecological focus areas (Dänhardt et al, 2018). These areas have the purpose to directly or indirectly conserve and improve biodiversity in agricultural holdings. Ecological focus areas can be land lying fallow, buffer strips, landscape features such as hedges and forests, protection zones, short rotation coppice, catch crops, and nitrogen fixing crops. In Sweden farmers with 15 ha or more are required to implement ecological focus areas on five per cent of their total arable land (Jordbruksverket, 2019). For implementing ecological focus areas subsidies are available from the Swedish board of agriculture. The requirements and exceptions for Swedish farmers to count area as ecological focus areas have been updated several times and today one of the requirements prohibit the use of plant protection products on legumes from the time of sowing until July 31st (Jordbruksverket, 2019). Through history several subsidies have been available and then also removed, both from the European Union and the Swedish government, more detailed information will be covered in the section about peas.

Import and export

Sweden both import and export grain legumes. In 2016 the import of fresh peas and beans, and dry peas and beans, all together approximately reached 12 091 tons (Strandberg and Persson, 2018). The same year around 63 390 tons of fresh peas and beans, and dry peas and beans was exported. The yield of dry peas and faba beans (excluding green fodder) in 2016 was around 196 000 tones (Ländell, 2017), which means that about 30 per cent of the domestic production was exported.

<u>Trends and previous studies</u>

Today several benefits of adding grain legumes in the cropping systems are known, such as their positive affect in the crop rotation and their nutritional qualities, but still they are not widely cultivated. A study by Magrini et al (2016) analyzed the French agrifood systems to find out the reasons for the low grain legume cultivation. The study found that

the majority of the plant breeding, the public subsidies and the food system has favored an increase in cereals over grain legumes which has led to a situation of technological lock-in. History matters and to increase the grain legumes part in the cropping system the study suggests four priority actions: increase genetic research, improve farmers' knowledge in managing rotations with legumes and especially using less mineral fertilizer, develop accounting tools to assess this benefit in monetary terms, and support food innovations to develop new outlets for grain legumes.

As the discussion about environmental issues and climate change are being highly debated, so is the choice of food we eat and its effect on the environment and our health. In the article *Less meat, more legumes: Prospects and challenges in the transition towards sustainable diets in Sweden,* Röös et al (2018) explored a future scenario for Swedish food consumption were meat consumption is reduced to 50 percent and replaced by domestically grown grain legumes. Their calculations show a 20 per cent reduction per capita climate impact, and a 23 percent reduction of land use, while nutritional values was still within the recommended range on a population level (with exception of pregnant women and those with specific nutritional requirements). This article also highlights agronomic benefits with adding more legumes to the crop rotation such as the symbiotic nitrogen fixation and the break crop effect in cereal-based cropping systems. It also mentions some challenges with an increased grain legume production, such as the need for better suited varieties for Swedish conditions (which are varying), the lack of processing facilities and the low consumer awareness about the health and environmental benefits of grain legumes. One of the main reasons for low environmental impact in the proposed scenario was the lower need for mineral N, due to the reduced need of cereals and oilseed crops for animal feed and that legumes does not require the same amount of added nitrogen since they in symbiosis with bacteria can fix much of the necessary nitrogen themselves. The report also mentions the benefits of higher yields of the following cereal crop grown after legumes, mainly due to the high residual plant-available soil N and improved soil structure, compared with cereal after cereal rotation. The study is important since it illustrates that if grain legumes were

cultivated on more area for human consumption instead of animal feed it can contribute to reduce the negative impact from agriculture while still produce enough food.

Another study that explore grain legume cultivation for human consumption in Sweden was carried out by Camilla Olsson (2017). Olsson wrote the master thesis about expanding the grain legume food production in southern Sweden with insights from producers and other representatives from the food industry. Through the study several challenges and uncertainty factors were identified through contact with farmers, wholesalers and processors, such as finding suitable varieties, weed and pest control management, suitable machinery for harvest and post-harvest handling, storage facility and profitability. Olsson's study several benefits with grain legume cultivation were well-known by the farmers who were interviewed, examples mentioned were the break-crop effect (diversification in the crop rotation), soil improvement and the symbiotic nitrogen fixation. These factors benefit the present grain legume and also the subsequent crop. From the processors perspective they also saw benefits of having legumes in their products as they have noticed an increased market opportunity and added value with products associated with the ongoing trend of plant-based and locally produced food. From Olsson's study, several challenges and success factors were identified and inspired this study to further investigate what affects uncertainty and variability, and how it has changed in time and with experience.

Food Consumption

According to a study from The Swedish Board of Agriculture written by Lööv et al (2015) people in Sweden eat more food per person in comparison with the consumption of food fifty years ago. An increase in consumption of both vegetables and meat have been noted. Some factors that were mentioned in the study to affect the consumption of food in Sweden were the income and price-variation, globalization and media. According to the Swedish National Food Agency (2019) a Swedish adult is recommended to eat 500 gram of fruit and vegetables (legumes included) per day, but in general the consumption only reaches around 360 gram (Lööv et al, 2015).

Lentil, *Lens culinaris*

Lentils originated from southwestern Asia as early as 7000 BC and the domestication started alongside the domestication of wheat, barley and pea (A. Samaranyaka, 2017). In west Asia and the Indian subcontinent lentils are of great importance for its low price and high nutritional value and is included in many dishes and traditional medicine (Yadav et al, 2007). Lentils have a high protein content and are a good source of many of the essential amino acids (A. Samaranayaka, 2017). Since 2008 Canada has been the top producer of lentils, followed by India and Turkey (FAOSTAT, 2019). The Canadian lentil cultivation began in the 1970' and today there are over 5000 active lentil farmers (Saskatchewan Pulse Growers, 2018). As a comparison there are approximately 3300 holdings in Sweden cultivating dry peas, faba beans or other beans (Olsson, 2018). In Sweden, lentils have traditionally been cultivated on Gotland, the so called "Gotlandslins" (Gotland- lentil) but until recently it was almost forgotten. (sprakochfolkminnen, 2018). Today the cultivation of lentils for human consumption is starting to increase and it is cultivated both on Gotland but also in other areas, mainly the southern parts of Sweden and Scania. Today the majority of lentils available for consumers are imported.

Pea, *Pisum sativum*

Pea has been cultivated in Sweden for a very long time, dated back to the Viking Age, 700-1050 A.D (sprakochfolkminnen, 2018). It is a crop that is used both for human food and animal feed. The areal has varied over the years due to several factors. Before the end of the 19th century pea flour was a common ingredient in bread, porridge and pancakes, then a lot of wheat, imported from America, began to replace the pea flour (sprakochfolkminnen, 2018). In the 20th century, at the time of the world war I and II the domestic pea cultivation in Sweden increased, mostly the kind for human consumption, due to the increased need for self-sufficiency of food (Jordbruksverket,1999). After the second world war the domestic production of pea declined until the 1970s when it started to increase again. In the 1980s several subsidies from the government was introduced for promoting Swedish food production and the pea cultivation highly

increased, this time mainly for animal feed. The subsidies ended in 1991, and during the same time period new quality-requirements for protein-fodder was introduced, which reduced the value of pea as a protein fodder crop. In 1995 Sweden joined the European Union, EU, and additional subsidies for legume production were introduced, which again increased the cultivation of peas (Jordbruksverket,1999). During the year 2013 subsidies for ecological focus areas were introduced and available for farmers with more than 15 hectares or more that cultivate legumes (nitrogen fixing crops) on at least 5 percent of the total arable land (Dänhardt et al, 2018). The requirements have been updated since the initiation and one important change was the prohibition of using plant protection products on those legumes cultivated on the ecological focus areas.

The pea is a traditional element in the Swedish kitchen. They can be used in various ways in various forms. A traditional way of serving pea in Sweden is in the dish ärtsoppa (pea soup) with the dry, yellow peas. Pea flour has historically been used to make bread, porridge and pancakes (sprakochfolkminnen, 2018). Another way of eating pea is as green peas, then the pea is harvested at an earlier stage and can be used as a fresh ingredient in a salad, or by itself as a side dish. Processed products such as drinks, ice cream and meat substitute are also ways of consuming pea.

Peas in Swedish agriculture

Peas cultivated for mature seeds, dry peas, were in 2018 cultivated on 21 670 ha and the harvest reached 48 900 tones, which gave an average yield of 2 260 kg/ha (Ländell, 2019). The average yield for mature peas during the time period 2013-2017 was 3 480 kg/ha (see table 1). In 2018 it was thereby a decline with 35 per cent from the 5-year average yield of pea cultivation in Sweden. The reason for the decline is according to the Swedish board of agriculture mainly due to the relatively warm and dry weather in Sweden during the spring and summer (Ländell, 2019).

Table 1. Area and yield of dry peas for the years 2013-2018 in Sweden. (Ländell, 2019)

Year	Area, ha	Harvest, tones	Yield, kg/ha
2018	21 670	48 900	2 260
2017	23 860	82 200	3 450
2016	25 170	92 700	3 680
2015	22 390	83 100	3 710
2014	14 450	46 500	3 220
2013	12 210	40 800	3 340
Average (2013-2017)	19 620	69 100	3 480

Method and material

In this study qualitative data was obtained through semi-structured interviews with farmers, traders, a plant-breeder and an agriculture-advisor, all working with yellow dry pea and lentil in Sweden for human consumption, as well as data from literature, reports and personal communication. Statistics of legumes and grain legumes in Sweden was obtained from reports carried out by the Swedish Board of Agriculture.

Method for interviews

To get a better understanding of the pea and lentil cultivation and trading in Sweden interviews were carried out with the aim to learn about the experience and future vision from several actors involved in Swedish grain legume cultivation and trading. All

interviews were performed in Swedish and have been translated into English. The interviews were in a semi-structured format, meaning that the interview-framework was structured with specific topics and some pre-prepared questions (list of topics and interview-questions can be found in appendix 1) rather than a strict protocol, which opens up for flexibility and new meanings to the topic of study (Galetta, 2013). All interviews had the same framework with the main topic to discuss and similar questions were asked to all interviewees. While asking questions and listening to the interviewees a time-line was created to identify variation and specific events. The use of a time-line is also a method to allow the participant to enter a more reflective space than simply answering questions (Guenette and Marshall, 2009) and is useful when trying to recognize patterns. The interviews were conducted during May 2019 over telephone as the interviewees were located far away, and also it was the wishes of the interviewees to have telephonic interviews as they were busy with farm or business activities. Additional information was obtained through communication over email after the interviews had been performed.

Selection of topics

A selection of topics were prearranged ahead to ensure that the interview would cover the specific area of research concerning grain legumes in Sweden. The topics were: Experience, challenges and uncertainty factors, success factors, communication/relation between farmer and trader, post-harvest methods, quality, demand and price, volume/areal, and future vision. The interviews had start and end-questions as well as some specific questions related to variation. During the interview questions related to these topics were asked. The time for the interviews varied between 20 to 50 minutes.

Selection of interviewees

In this study many of the interviewees are participants of the Swedish DiverIMPACTS case study and they were contacted first for interviews. Actors non-related to the DiverIMPACT case study were also interviewed. A total of three farmers (two cultivating lentils and one cultivating yellow peas), three trading companies (one trading with lentils, one with dry peas, and one that trades with both dry peas and lentils), a plant breeder and a crop-advisor were interviewed.

Interviewees

Farmer 1, lentils

- Farm with crop cultivation, poultry breeding and livestock
- Cultivates several crops including lentils, oats, wheat, carrots and lupin
- Has cultivated lentils in larger scale since 2016, had smaller trial fields before
- Located in Scania
- KRAV-certificated farm

Farmer 2, lentils

- Organic farm that cultivates several crops including lentils, beans, quinoa, onions and carrots
- Has cultivated lentils since 2012
- Located in Scania

Farmer 3, dry peas

- Cultivates several crops including yellow peas, brown beans, ley and rape seed
- Yellow peas have been cultivated for a long time, over two generations
- Located on Öland

Crop advisor

- Works with crop production mainly in Scania
- Has experience of both lentil and pea cultivation, as well as other grain legumes

Plant breeder, lentils

- Field experiments performed since 2017
- Aim is to try out different varieties that can be suitable for Swedish climate and agricultural
- Both organic and conventional field trials
- Works at the research department at Lantmännen

Nordisk Råvara

- Trading company founded in 2016 selling niche-product of domestically cultivated grain legumes
- Provides farmers with seed and then buy and trade the produce
- Nordisk Råvara perform quality-control, drying, cleansing, packing, labeling and trade to wholesaler and the food industry

Kalmar Öland Trädgårds Produkter, KÖTP

- Economic association owned by 120 Swedish farmers founded in 1959
- Produce and trade with Swedish beans, peas and onions
- KÖTP perform quality-control, drying, cleansing, packing, labeling and trade to wholesalers and the food industry

Lantmännen

- Agricultural cooperative owned by 25 000 Swedish farmers
- International market with Sweden as base
- Produce and trade several crops, including dry peas and imported lentils, as well as working with research and innovation

Results from interviews

In table 2 the success factors in cultivation and trade for both yellow dry peas and lentils are compiled, as well as the success factors only mentioned for yellow dry pea and only for lentil. Each factor is then further explained below the table. Table 3 shows the main factors causing variability and uncertainty in cultivation and trade, in time and with experience, followed by further explanation and how the actors are managing those uncertainties and their suggestions on improvements. Last is a section with the participants future vision of cultivation and consumption of yellow dry pea and lentil in Sweden.

Table 2. Success factors for cultivation and trade of yellow dry pea and lentil

Yellow dry pea & lentil	**Yellow dry pea**	**Lentil**
High nutritional value	Pea soup	Many areas of use
Agronomic benefits		Niche-product
Increased demand for plant protein		
Good relation between farmer and trader		

<u>Success factors, yellow dry pea & lentil</u>

High nutritional value

All actors in this study mentioned the high nutritional value as a success factor for cultivating and trading with yellow dry peas and lentils.

Agronomic benefits

The ability of the two grain legumes to fix atmospheric nitrogen and thereby reduce the

need for synthetic fertilizers and promote soil health was mentioned by several actors, as well as being good pre-crops and break-crops in the crop rotation.

Increased demand for plant protein

All actors in this study said that they have noticed a higher demand for plant protein from consumer.

Good relation between farmer and trader

Both farmers and traders expressed the relation between the actors to be good. They described that for each year the farmers and trading companies sign a contract of how many hectares to be cultivated, then the trading company provide the farmer with seeds, the farmers cultivate the crop and then deliver the harvest to the trading company that takes care of the post-harvest handling with cleaning, sorting and packaging. The trading company KÖTP described that they work for the farmers to get the best possible return for their harvest. The pea farmer also mentioned that in years when subsidies for cultivating legumes had been removed, or the requirements had been changed, the trading company had adjusted the price so that the farmers still would get a good return for their harvest. Nordisk Råvara that trade with lentils mentioned that they have built a good relation with their contracted farmers, but the informant did not want to explain further due to trade secrecy. The lentil farmers also expressed that the relation was good but did not give any further information.

<u>Additional success factors, yellow dry pea</u>

Pea soup

The actors working with yellow dry peas said that today the consumers mainly want yellow dry peas to make the traditional Swedish dish pea soup (*ärtsoppa*). It has therefore been cultivated and consumed for a long time for that specific purpose and is one of the reasons mentioned by the actors when asked why they have chosen to cultivate the crop. The actors also described that they have noticed that the demand is stable for each year, but it is not increasing. For an increase in yellow dry pea cultivation and consumption the actors said that other areas of use must be applied.

Additional success factors, lentil

Many areas of use

An additional success factor with lentils was mentioned by the farmers and the informant from the trading company Nordisk Råvara to be the many areas of use in numerous dishes, both warm and cold

Niche-product

Both lentil farmers in this study expressed that they have a high interest in cultivating lentils since it is a niche-product in Sweden today. Farmer 2 also said that since lentil is a crop that can be cultivated in Sweden, it should, to increase both the diversity in the cropping systems and the self-sufficiency level.

In table 3 the factors causing variability and uncertainty in cultivation and trade for both yellow dry peas and lentils are compiled, as well as the factors only mentioned for yellow dry pea and only for lentil. Each factor is further explained below the table, as well as how the actors act to manage the variability, and how it can develop.

Table 3. Factors causing variability and uncertainty in cultivation and trade, in time and with experience

Yellow dry pea & lentil	**Yellow dry pea**	**Lentil**
Consumer demand	Areas of use	Low & varying yields
Economic incentives & subsidies	Pest & pathogen attacks	Harvest-method
Weather conditions	Increased cultivation of faba beans & other beans	Post-harvest processing
Suitable varieties	Autumn sown crops	Low consumer awareness

Factors causing variability and uncertainty, yellow dry pea and lentil

Consumer demand

As mentioned above, all actors in this study said that they had noticed an increased demand for plant protein sources and grain legumes in recent years. The actors working with yellow dry pea explained that the demand for yellow dry peas has mainly been for pea soup has been stable, but not increasing. To increase the demand for yellow dry peas in general, the informant from Lantmännen replied that they believe in a "*Revival of the pea",* in other dishes and products, perhaps as a Swedish equivalent of the chickpea. To respond to the demand, even in years when the harvest has been low such as in 2018, both trading companies working with yellow dry peas said they have a surplus storage. The informant from Lantmännen described that he area of yellow dry pea cultivation is changing between years depending on the demand and also the area of other crops cultivated in autumn. The larger area dedicated to autumn sown crops, the smaller area for pea cultivation the following year.

The actors working with lentils said that they have each year since the start increased the cultivation area, except for Farmer 2 who was satisfied with the area and rather wanted a variety of crops each year. Farmer 1 explained that in 2016 he cultivated lentils on 3 hectares and in 2017 and 2018 he expanded to 6 hectares. The trading company Nordisk Råvara also said that their goal has been to expand the cultivation area for each year. Due to the high demand and the relatively low available volume, the informant said that each year they have sold every batch they receive and can therefore not keep a surplus storage.

Economic incentives and subsidies

According to Farmer 3, the economic return he gets from peas has increased in recent years, which he said could be the result of a higher demand from consumers and also the lower yields. The company that he works with and delivers the peas to are KÖTP, and they work to adjust the price so that the farmers gets the best possible return for their produce. Farmer 3 also mentioned that the subsidies available have been very important for the pea cultivation to be economically sustainable. He described that when

one subsidy was removed a few years ago, the trading company KÖTP compensated the farmers with a better economic return on their produce, which Farmer 3 expressed was very good and needed for him to keep cultivating peas. The informant from KÖTP also mentioned the governmental subsidies available for farmers to be important. When subsidies have been removed or the requirements for the application have changed it has also affected the number of farmers and the cultivation area for yellow dry pea.

With the increased demand for plant protein sources in recent years, the trading companies also mentioned that they have noticed an increased willingness to pay more for domestically cultivated crops, which has increased their ability to compete with imported peas and lentils on the market. The trading company working with lentils also mentioned that they have noticed an added-value with labeling the product with the specific origin and farm where it was cultivated, as well as Swedish lentils being a niche-product not easily accessible.

Weather conditions

Another factor mentioned by the participants to affect yield and quality was the weather conditions. In 2017 harvesting for both lentils and peas were difficult due to heavy rainfall during the harvest period. The lentil famers also explained that the lentils that year began to sprout out in the field and could therefore not be sold for human consumption. They both had tried to harvest parts of the field early, to let the seeds mature after harvest, but many seeds had turned out wrinkled and did not meet the quality requirements for human food. In 2018 the weather was very dry which also resulted in lower yields for both lentils and yellow dry peas, as well as reduced and uneven quality. The pea farmer also said that the weather can highly affect the yields, which has varied between 2000 to 4000 kg/ha. One of the lentil farmers described that his best year had been in 2016 and then the harvest had reached 1200 kg/ha, compared to the following to year 2017 that resulted in 400kg/ha, and 2018 that resulted in 200 kg/ha. All farmers and traders said that in years when the weather, pests, or pathogens have caused a reduced quality on the harvest, when it does not fulfill the requirement for human food, the harvest can still be sold as animal feed. When the harvest is sold as animal feed it results in a lower economic return.

Suitable varieties

When asked about the experience with uncertainties and challenges for cultivating lentils both farmers pointed out the yield variability and the lentil's poor ability to compete with weeds. They commented that they have experimented by growing different varieties of lentils and also cultivating lentils together with other crops to suppress the weeds. Farmer 1 said that in 2016 he successfully tried clover as a ground crop to suppress weeds while supporting the lentil to stand up higher. Farmer 2 mentioned that he intercropped lentils with oats, which also showed to have a good effect on the abundance of weeds and helped to support the lentil plant to stand upright. Both farmers mentioned that they are collaboration with researchers to share knowledge and to keep learning about different lentil varieties and agricultural methods with the aim to find better and improved ways of cultivating lentils in Sweden. Varieties that grow taller, produce higher yields and that can compete better against weeds were therefore mentioned as necessary traits to look for in order to improve the cultivation. Suitable agricultural practices such as intercropping and harvest method was also mentioned as areas of improvement.

The farmer cultivating yellow pea and the two trading companies working with yellow dry peas mentioned that today it is mainly one variety that is cultivated for human consumption, called *Clara.* They said that they experience that the plant breeding has been more focused on yield and productivity rather than cooking qualities, and that the aim has mainly been for animal feed instead of human food. The crop adviser said that today there are relatively few farmers that cultivate yellow peas for human food compared to animal feed. Both trading companies, KÖTP and Lantmännen, mentioned that they have continuous field trials and are trying out different varieties for improved productivity and cooking qualities.

<u>Additional factors causing variability and uncertainty, yellow dry pea</u>

Areas of use

As mentioned above, the demand for yellow dry peas for the traditional Swedish dish

pea soup (*ärtsoppa*) has for a long time been the main area of use of yellow dry peas for human consumption. Both the farmer cultivating pea and the two trading companies working with yellow dry peas said that for an increase in cultivation area and consumption, new areas of use need to be applied, such as innovative products and recipes. The informant from Lantmännen also replied that an important area of improvement for them is to reach out to the market and make consumers aware of all the benefits with yellow peas.

Pest & pathogen attacks

According to the pea farmer and the crop advisor, pest and pathogen attacks were also factors causing variability and uncertainty in the cultivation. Birds and wild boar can be a huge problem since they enjoy eating the peas. It affects the harvest and the quality of the produce and then subsequently lower the price.

Increased cultivation of faba beans & other beans

When looking back in time, the crop-advisor said that around twenty or thirty years ago yellow peas were highly cultivated, since then there has been an increase in the cultivation of faba beans, mainly for animal feed. The crop advisor remarked "*Faba beans are safer to cultivate than peas and it also has a higher potential yield*". The pea farmer also said that his cultivation area for yellow peas has been reduced since he started cultivating more beans. Peas and beans are susceptible and can be host plants to several similar plant diseases and therefore they cannot be cultivated to close in the crop rotation.

Autumn sown crops

As mentioned above, the informant from Lantmännen, described that he area of yellow dry pea cultivation is changing between years depending on the demand and also the area of other crops cultivated in the autumn. The larger area dedicated to autumn sown crops, the smaller area for pea cultivation the following year.

Additional factors causing variability and uncertainty, lentil

Low & varying yields

The lentil farmers both mentioned that from a yield per unit area perspective, lentils are not the most productive grain legume to cultivate. Farmer 1 said that in his fields other grain legumes, such as faba beans and lupin, produce higher yields compared to lentil. He also said that he believes that for farmers to keep cultivating lentils in a long-term perspective, either the yields have to increase, or the price must rise for it to be economically sustainable. Farmer 2 mentioned that the indeterminate growth of lentil, that the plant will continue to grow and produce flowers until conditions are no longer favorable, was a challenge. He explained further that the lentils plants are usually harvested when most of the lentil seeds have matured. Farmer 2 also said that he has cultivated lentils on 1-2 hectares each year since 2012 and is satisfied with that area. His aim is to cultivate a variety of grain legumes to offer consumers, as well as a having a diverse crop system to reduce the risk of high losses in bad years.

The informant of the trading company Lantmännen, that so far only has traded with imported lentils, said that due to lentils being a relatively new crop cultivated in Sweden in limited extent the access of Swedish lentils in bigger volumes is an uncertainty factor. For Swedish lentils to be successful the informant described that the yields and total volume must increase.

Harvest-method

In terms of harvest, both lentil farmers described that since lentils grow very close to the ground, they are more difficult to harvest compared to other crops. The combine needs to be close to the ground, but careful not to also collect a lot of stones. The same kind of combine is also used for other grain legumes. Farmer 1 (that has cultivated lentils for three years) expressed harvesting as a difficulty from start until today, compared to Farmer 2 (that has cultivated lentils for seven years) that expressed the harvesting to be more of a difficulty when he first started cultivating lentils but that it is less of a problem today.

Post-harvest processing

When asked about post-harvest methods, Farmer 2 mentioned that when he started growing lentils (around 2012) he thought it was difficult to clean and sort the harvest, but today he has invested in his own machines which allows him to handle every step from cultivating the lentils to have them packed and sold to costumer. On his farm he also cultivates other grain legumes and his aim is to have a variety of crops in smaller volumes. Farmer 1 talked about post-harvest activities as a big challenge. He would like to have the cleansing and sorting places where the harvest can be sent to be closer to his farm, to avoid long distance transportation. He mentioned that a mobile cleaning, sorting and drying machine would be a good solution. The crop advisor said this is a problem for many lentil farmers and that development in the post-harvest area with a higher capacity and availability to cleaning and sorting places is necessary for increased cultivation. The informant from the trading company Nordisk Råvara also said that more actors in the value chain, such as companies that can processes the lentil seeds into flour or create new innovative products would benefit the possibility to increase lentil cultivation and consumption.

Low consumer awareness

The informant from Nordisk Råvara expressed that he predicts a bright future for lentils. He said that he believes more people will discover lentils as a good and healthy ingredient and that the demand will continue to increase. To increase consumers' awareness of lentils, he suggested that lentils should be served more frequently in schools and at work places that has their own restaurant. It could be a more natural way for people who may not otherwise consider trying lentils to be introduced to them.

Future vision

All participants in this study said that they predict a bright future for yellow dry pea and lentil cultivation. The main areas of improvements were described as more plant breeding for varieties suitable for human consumption, further research on efficient agricultural practices and harvest-methods in lentil cultivation, more actors working with

post-harvest and innovation of new products, and increasing the consumers' awareness all the benefits with yellow dry peas and lentils, both nutritional and for the environment.

Discussion

From the qualitative semi-structured interviews in this study with farmers, a crop advisor, a plant breeder and trading companies working with grain legumes in Sweden, more specifically yellow dry peas and lentils, important factors affecting variability and uncertainty was explored as well as the participating actor's vision of the future and the development of pea and lentil cultivation and consumption in Sweden. The results in this study is from the experience of a few selected actors in the value chain of yellow dry pea and lentils in Sweden today. It can therefore not be representative for all farmers, traders, plant breeders and crop advisors working with yellow dry peas and lentils, but is still hopefully a valuable contribution for the understanding of factors causing uncertainty and variability in cultivation and trade today and in the past, to make the future less uncertain.

The main factors causing variability and uncertainty in cultivation and trading of both yellow dry peas and lentils were: consumer demand, economic incentives and subsidies, weather conditions, availability of suitable varieties for human consumption and cultivation in Sweden, post-harvest processing and areas of use. The results from this study goes in line with several of the findings in Olsson's study (2017) about uncertainty factors and areas of improvement. The results also display the importance of having several actors working together for development, from both the supply and the demand side (Smith et al, 2014; Magrini et al, 2016) including farmers, consumers, researchers, entrepreneurs, innovators, journalists and policy makers.

Several ways of managing the variability and uncertainty factors was described by the interviewees in this study such as the alternative to sell the produce as animal feed if it did not meet the requirements for human consumption, cultivating several crops on the farm to add diversity and reduce the risk of high losses in years with bad weather or pest and pathogen attacks, apply intercropping with oats or clover, collecting a storage in good years as a security if the subsequent year's harvest is low, the continuous research and field trials of different pea and lentil varieties to find more suitable and productive alternatives, adjusting the price so it covers the costs, and to apply for the available subsidies when cultivating legumes.

To raise the consumer's demand suggestions from the interviewees on areas of improvement included the need to raise awareness of the many benefits of consuming grain legumes, both for the environment and the human health, as well as advertise the many areas of use in cooking and as an ingredient in processed products. Media is known to have high impact on our consumption habits (Lööv et al, 2015) and by increasing the presence of grain legumes and their many benefits and areas of use in media platforms such as newspapers, magazines, television-programs, cooking-shows, and through the several modern influencers on social media, the awareness and consumption of grain legumes would most likely increase. Adding more grain legumes in school restaurants and working places as well as introducing other ways of cooking grain legumes, were also suggestion from some of the interviewees that could encourage more people to try grain legumes and increase the consumption. Röös et al, (2018), have also raised the importance and need for including more legumes in Swedish diet.

The informant from Lantmännen described the cultivation area of yellow dry peas to be related to the area of autumn sown crops. The more area for autumn sown crops the less area for peas the following year. In 2018 cereals were cultivated on approximately 38 per cent of the Swedish arable land and legumes were cultivated on approximately 2 per cent (Jordbruksverket, 2018). Both cereals and legumes have a nutrient composition

with several functional properties and health benefits, but cereals are a poor source of the essential amino acid lysine which grain legumes have an abundance of, while the grain legumes have a low amount of methionine which is abundant in cereals (Kumari and Sangeetha, 2017). The combination of cereals and grain legumes would thereby form a complete set of essential amino acids in food. Inclusion of more grain legumes in our diet has been strongly recommended by the recently published The EAT-Lancet report (2019). The question of why grain legumes are not more present in the cropping systems was raised in the study by Magrini et al (2016) and the authors provided an answer by describing that the cropping system is in a situation of technological lock-in as a result from the co-evolution of crop system based on an agrochemical paradigm, public policies, and a market dynamic that has promotes cereals through factors such as more intense plant breeding for cereals compared to grain legumes, availability of public subsidies for cereal cultivation and the high presence of cereals in the food system. The study also describe that grain legumes have in European institutions been referred to as animal feed for a long time, instead of food for humans. The results from Magrini et al's study goes in line and can be related to the situation that the interviewees mentioned in this study. Several actors described the need of research for better suitable varieties for Swedish conditions and human consumption, both for peas and lentils, as well as improvements in agricultural practices and post-harvest technology. The availability of subsidies has been shown to be an important factor affecting the area of pea cultivation in Sweden through history (Jordbruksverket,1999) and was also expressed in this study. The majority of the yellow peas cultivated in Sweden have been used as animal feed and therefore the main research and economic incentives have been towards yield and productivity instead of cooking-properties and taste.

According to the statistics from the Swedish Board of Agriculture (Lööv et al, 2015) the consumption of vegetables has increased, but the average Swedish person is still eating less vegetables, fruits and grain legumes than the recommended amount of 500 gram per day. The informant from Nordisk Råvara described that they have experienced an increased demand from both farmers wanting to cultivate more grain legumes well as buyers wanting to buy bigger volumes of the produce. Due to limited capacity in handling

and processing the company has not been able to respond to the high demand. A similar dilemma was described with the lentil farmers, the demand has been high but due to limited lentil varieties available that are suitable for Swedish conditions (weather and agricultural practice) the volumes harvested have not been able to respond towards the demand. The farmer cultivating yellow peas as well as the trading companies working with peas described the demand for yellow dry peas to be stable and suggested to find other areas of use to increase the demand and consumption. The pea farmer and KÖTP also described a need for better yellow pea varieties suitable for human consumption with lower susceptibility to pest and pathogens as well as improved cooking properties. The statistics of the food consumption in Sweden (Lööv et al, 2015) and the answers of the interviewees in this study imply that there is an increased demand for plant based nutrient sources, perhaps more for niche-products such as lentils than traditional yellow peas when in terms of grain legumes, and that the possible area cultivated, and the recommended amount of vegetables consumed is still not reached. A higher share of grain legumes in the cropping system would promote biodiversity which could financially benefit the farmer by an increase in natural enemies of pest and pathogens that could reduce the need of pesticides and other external inputs, as well as reducing the vulnerability to severe yield loss (Lin B, 2011). Adding more grain legumes in the Swedish cropping system could also reduce the negative climate impact from the agricultural sector by reducing the use of synthetic nitrogen fertilizer that is causing high emissions of greenhouse gases and that is negatively affecting the natural cycle of nitrogen in the environment (Raven et al, 2005; Röös et al, 2018).

Conclusions

Agriculture is commonly seen as both a reason and a part of the solution for many of the known challenges that we face today, including climate change, food security and biodiversity loss. Depending on what choices we make, as consumers, producers, influencers or policy makers, we affect what tomorrows challenges will look like. In this study several benefits with grain legumes have been mentioned, such as the agronomic

benefits with improved soil health and reduced use of synthetic nitrogen fertilizer, as well as the high nutritional value of grain legumes for human consumption. To increase the cultivation and trade of lentils and yellow dry peas for human consumption in Sweden the uncertainty factors causing variability must be reduced. With further plant breeding of grain legume varieties for human consumption and research on suitable agricultural practices (intercropping, harvest methods and post-harvest methods, etc), as well as offering public subsidies for domestic grain legume cultivation, introducing more actors working with processing and creating new products and areas of use with grain legumes the uncertainty factors causing variability among the Swedish farmers and traders in this study could possibly be reduced and the cultivation area of grain legumes for human consumption in Sweden could increase.

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Appendix

Appendix 1: List of topics and interview questions

List of topics:

- Experience
- Success factors
- Challenges and uncertainty factors
- Area and harvest
- Demand and price
- Quality
- Communication and relation between farmer and trader
- Collaboration
- Post-harvest methods
- Future vision

Opening questions:

- Tell me about your business
- Why do you cultivate/trade with lentils/yellow dry peas?
- How do you sell the lentils/peas?
- What challenges do you experience with cultivating/trading with lentils/yellow dry peas?
- What is your definition of quality in terms of lentils/yellow dry peas?

Questions related to time-line:

- When did you start cultivating/trading with lentils/yellow dry peas?
- How has the area and harvest/volume changed between the years? What do you believe could be the reason for that?
- How has the price changes between the years? What do you believe is the reason for that?

- How has the quality changes between the years? What do you believe is the reason for that?
- Have you had specifically good years?
- Have you had specifically bad years?
- What is your strategy to manage variability and uncertainty in harvest/volume/price/quality?
- Has there been any specific events that has affected your business?

Ending questions:

- How does your future vision look for lentils/yellow dry peas in swedish cultivation and consumption?
- What do you see as areas of improvement?
- Would you like to add something more?