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# Inventory Report on Market Research on RDFs– (Demand Chain) in the Horticulture Sector

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# Summary

The use of recycling derived fertilisers (RDFs), which are sustainable recycled fertilisers that come from a variety of sources, in agriculture across Europe, has been slow to date. However, through greater awareness of the benefits of RDFs, emphasis on sustainable agriculture and the impact fertilisers have on emissions, coupled with current supply issues of mineral fertiliser due to, Covid-19, the China export ban and sanctions on Russia, it is envisaged that the end-users such as farmers are more informed and encouraged to consider mineral fertiliser alternatives. In addition to the agricultural market, there is a sufficient gap in the horticulture sector, which has excellent potential for the use of these RDFs.

The trends in global fertiliser prices, fertiliser sales and land use were explored in this research with the same trends investigated across North-West Europe (NWE), specifically Belgium, France, Germany, Ireland, Luxembourg, the Netherlands and the United Kingdom to understand the current fertiliser situation in Europe and give an insight into fertiliser use in the future. To assess the potential demand for RDFs in the horticulture sector, the size of the sector in terms of the number of horticulture farms, the area of land used in horticulture and how horticulture contributes to the economy in NWE were also evaluated.

The price of fertilisers globally is increasing, however, this increase varies depending on the type of fertiliser used, such as urea ammonium nitrate or potassium chloride and the NWE countries' regional demand. Fertiliser sales, in particular nitrogen and phosphorous also varied per country, depending on their availability and use. However, this data was only available up to 2019 and does not take into account the effect the Russia-Ukraine war has had on fertiliser sales. In terms of agriculture in Europe, in 2020, up to 30% of the total land area was used for agriculture production. Nitrogen is the most used nutrient in the EU and between 2010 and 2019, the Netherlands and Belgium were the most dominant users.

In terms of the demand for RDFs in the horticulture sector, due to the increase in fertiliser costs and their lack of availability across NWE, there is a considerable gap in the market for their use. The Netherlands is the second largest exporter of agricultural and food products in the world. It is one of the main producers of fruit and vegetables, and supplies about a quarter of the vegetables for export to Europe. Up to 22% of all agricultural production can be classified as horticulture in Belgium. France accounts for more than one-fifth of the total value of output, and is responsible for more than one-third of the EU's production of wine. In Germany, the ornamental horticulture sector produces on average 1.5b bedding, balcony, herbaceous and perennial plants a year. In Ireland, strawberry production accounts for over 90% of Irish berry production and is worth approximately 47m euros annually. And horticulture in the UK accounts for about 3% of the UK's agricultural area.

Although global and European statistics are available with this information, there is, however, a lack of up-to-date current data, contributing to the difficulty in predicting what will happen in the horticulture sector in the future concerning the use of fertilisers and therefore impacting our ability to forecast future trends and inputs. However, it can be concluded that the use of RDFs in the horticulture sector would reduce the reliance on mineral fertilisers, reduce fertiliser costs and would actively contribute to the circular economy.



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# Abbreviations

Billion
Calcium ammonia nitrate
Capitalisation
Central Statistics Office
Diammonium phosphate
European Union
Hectares
Potassium
Kilogramme
Potassium oxide
Million
Megaton
Nitrogen
Not applicable
Nomenclature of Territorial Units for Statistics
North-West Europe
Phosphorous
Phosphorus pentoxide
Recycling-Derived Fertilisers
Tonne
Triple Superphosphate
Utilised Agricultural Area
United Kingdom



# **1** Introduction

The Interreg North-West Europe (NWE) funded project ReNu2Farm Capitalisation (CAP) aims to increase the acceptance of RDFs by farmers and evaluate the potential use and demand for RDFs in new sectors including the horticulture sector.

Horticulture is a branch of agriculture that is associated with nurseries, gardening services, cemetery gardening, gardening supplies retailers, garden centres, florists and landscape gardening. In addition, the production of fruit, vegetables, salads, herbs, spices (EPSO, 2013) and ornamentals contribute to this sector. The fruit and vegetable sector alone accounts for 14% of the total value of agricultural production in the EU in 2018 and has an annual output of over 57b euros (European Parliament (2019a) In addition, the EU is the biggest producer of flowers, bulbs and potted plants with 44% of total global production (European Commission, 2019a). The ornamental plant sector has an estimated turnover of 20b euros in production (Roy, 2022).

In terms of fertiliser, phosphorus (P), potassium (K) and nitrogen (N) are essential elements for plant nutrition and growth. Phosphorous cannot be substituted with any other mineral and it is of high economic importance. Phosphate rock minerals resources are the only significant global source of P. Globally there are approximately 71b metric tons of phosphate rock reserves, with the highest reserves located in Morocco with approximately 50b metric tonnes (Deloitte Sustainability, 2017). However, the mineral reserves of rock phosphate are being depleted globally and in 2014 the European Commission added rock phosphate to its critical raw materials list (EC, 2014) as the supply security is at risk.

The majority of the world's reserves of K are recovered by underground mining methods. Canada has the world's largest potash reserves, which exceeded 3.7b metric tonnes in 2019 (Garside, 2021). Nitrogen fertiliser is heavily dependent on natural gas for its production via the Haber-Bosch process, with consumes on average 1–2% of the world's annual primary energy supply and generates more than 300Mt of fossil-derived carbon dioxide per year (Tanabe et al., 2013). This energy-intensive process, therefore, incurs high fuel costs, which in turn drives up the costs of mineral fertiliser. Russia is a major exporter of potash, ammonia and urea, however, sanctions imposed on Russia by the EU due to the Russia-Ukraine war, have disrupted exports, shipments and supply of these fertilisers globally (Polansek et al., 2022).

Global fertiliser costs are increasing annually due to a variety of factors including import and energy costs, distribution and supply chain, and as a result of a shortage of labour and the shutdown of several fertiliser plants due to the Covid-19 pandemic. The Russia-Ukraine war has also impinged on fertiliser sales due to sanctions imposed by the EU, therefore affecting the fertiliser supply globally (Polansek et al., 2022). In 2020, the global fertiliser market summed up to more than 158b euros. In addition, it is predicted that the fertiliser market will exceed 195b euros by 2027 (Fernández, 2021).

However, on average, the annual fertiliser sales rate is decreasing across North-West Europe (NWE) with many farmers in Europe deciding to change or substitute chemical fertilisers with organic forms. It has been reported that sales of N have decreased by 12% between 2014 and 2019, with sales of P reducing by 21% between 2011 and 2019, and K sales decreasing by 5% between 2010 and 2019 (Eurostat, 2021b). Organic fertilisers have an important role



in following sustainable organic farming by the farming community, such sustainable fertilisers include RDFs.

Recycling derived fertilisers are sustainable recycled fertilisers that come from a variety of sources across Europe. They are a by-product of, not only the farming industry but also domestic sources, wastewater treatment and commercial industries. These types of fertilisers are a rich source of NPK that are essential for crop growth. In addition, some RDF products have the potential to increase the organic and humus content in the soil, increase the soil's microorganism communities and overall increase soil fertility, making RDFs excellent sustainable alternatives to mineral fertilisers These recycled products come from several different sources, all of which are waste by-products, such as animal manure and sewage sludge (Egan et al., 2022). There are many different RDF products derived from recycled sources, however, composting and digestates are the most commonly known and are typically used as organic soil enhancers (Egan et al., 2022).

Although there is a growing demand for sustainable mineral fertiliser alternatives in the agricultural sector, it is important to explore the potential use of RDFs in new markets. Previous research conducted by Egan et al. (2022), explored the desired properties and acceptance of RDFs by farmers and found that farmers are interested in using RDFs, if not already using them to some degree. To expand on this knowledge, it is important to examine new sectors for these products, such as the horticulture industry. This research aims to (a) assess the current fertiliser market by investigating the cost, use and sales of fertilisers in NWE, (b) determine the number of horticulture farms in NWE, the horticulture land use, the types of horticulture practices (indoor, outdoor, vineyards etc.) and how much this branch of agriculture is worth to the economy, and (c) evaluate if there is a potential market for RDFs in the horticulture sector.

# 2 Methodology

The sources of data obtained for this report are recorded in Table 1. The Nomenclature of Territorial Units for Statistics (NUTS) refers to a standardised referencing system for European countries for statistical purposes. The standard was developed by and is regulated by the European Union. The data for the number of horticulture farms, UAA in horticulture and standard horticulture output was displayed at the NUTS 2 level, often displaying the regions with the highest recordings. Please note: In 2003, when the NUTS categories were introduced, Ireland was divided into two NUTS 2 regions – the Southern & Eastern region and the Border, Midland & West region. In 2014, the Local Government Act was introduced which made several changes to administrative boundaries in Ireland, therefore Ireland revised its NUTS 2 and NUTS 3 statistical regions to match these new boundaries (European Union Commission Regulation (EU) 2016). Although the changes to the NUTS boundaries were given legal status in 2016, they were not put into force until mid-2018 (WDC Insights). Any data presented in this report from 2016 or prior are using the 2003 categories.



## 2.1 Global and NWE Fertiliser Prices

The global fertiliser price data were obtained from the World Bank Commodities Price Data (The Pink Sheet, 2022) and were available in US dollars (see Table 1). The data was accessible from the year 1960 to 2021, however, for the scope of this research, the data for urea, diammonium phosphate (DAP) and potassium chloride from 2008 to 2021 was utilised. The data was converted into euros by using the conversion rate of 1 Dollar = 0.91 euro, as of the 15<sup>th</sup> of March 2022. The data was displayed from 2008 to 2021 to assess how the global fertiliser price in euros per tonne, had fluctuated annually. The mean (average) value over 13 years was also included in the figure as a visual reference.

Fertiliser price data for Belgium was acquired from Statbel (Algemene Directie Statistiek - Statistics Belgium). The data was available from 2015-2020 and was displayed as euros per tonne. In addition, the data for the economic accounts for horticulture in Belgium was also obtained from Statbel, which describes the output for various horticulture products in Belgium from the years 2016 to 2020, with forecasted results for 2021, where the data is displayed in millions of euros.

Price data for France came from ARVALIS - Institut du vegetal and was available from September 1998 to April 2022. However, for the scope of this research, the data from August 2020 to April 2022 were displayed. In addition, the average price of the different fertilisers for 2008-2022 was also reported. The data for N was originally displayed as constant euros/kg N, K was displayed as constant euros/kg K<sub>2</sub>O and P fertilisers as constant euros/kg P<sub>2</sub>O<sub>5</sub> with the price corrected with inflation. For consistency, K<sub>2</sub>O and P<sub>2</sub>O<sub>5</sub> were converted to elemental P and K by multiplying the value by 0.8301 or 2.2910 respectively (Reiter, 2020).

Region	Data	Statistical Level	Data Source
Globally	Global fertiliser price (euros/t)	NA*	World Bank Commodities
All NWE countries	Fertiliser sales ('000t)	NA	Eurostat
	Fertiliser use -Input (kg/ha)	NA	Eurostat
	Agricultural land use ('000 ha)	NUTS 2	Eurostat
	Horticulture farms	NUTS 2	Eurostat
	Agricultural area used for horticulture (UAA ha)	NUTS 2	Eurostat
	Horticulture output ('000,000 euros)	NUTS 2	Eurostat
Belgium	Fertiliser price (euro/t)	NUTS 2	Statbel (Algemene Directie Statistiek - Statistics Belgium)
	Greenhouse companies and horticulture holdings (ha) Economic accounts for horticulture	NA	Statbel
France	Fertiliser price euro/t of N, K <sub>2</sub> O or P <sub>2</sub> O <sub>5</sub>	NUTS 2	ARVALIS - Institut du vegetal
Germany	Fertiliser price (euros/t)	NUTS 2	Chamber of Agriculture Germany
Ireland	Fertiliser price (euros/t)	NUTS 2	Central Statistics Office
Luxembourg	Fertiliser price (euros/t)	NA	Lëtzebuerg Farming Portal
Netherlands	Fertiliser price (euros/t)	NUTS 2	Wageningen University
	Outdoor horticulture farm number and area (ha)	NA	StatLine
United Kingdom	Fertiliser price (euros/t)	NUTS 2	Agriculture and Horticulture Development Board (AHDB)

Table 1: Summary of the sources, distribution and statistical level of data used in this report.

\*NA- Not applicable



Fertiliser prices in Germany were obtained from the Chamber of Agriculture in Germany (Chamber of Agriculture, 2022). The data was available for weekly fertiliser prices, therefore the annual average was calculated for the years 2014-2021. The data referring to the price of fertiliser in Ireland was obtained from the Central Statistics Office (CSO, 2022b). The data is presented as the price of urea and potassium chloride in euros per tonne from the years 2008 to 2021 to assess how the fertiliser price in Ireland had fluctuated annually. The price of superphosphate data was only available from the years 2012 to 2017 and 2019 to 2021.

The cost of fertiliser in Luxembourg was sourced from the Lëtzebuerg Farming Portal (2022), which described the price in euro/t. The data was available from 2002 -2021, however, for the scope of this research data from 2008 on, was reported. In many instances, there were knowledge gaps in the data where there are years of data missing, in particular the years 2013-2015 are lacking for all fertiliser types reported for Luxembourg. The data for the price of fertilisers in the Netherlands was obtained from Wageningen University and describes the price of various fertilisers each month for the year 2021 and for January and February 2022 in euro/kg. The data was converted to euro/t for consistency within this report. This data offers monthly insights into the developing trends of fertiliser prices in the Netherlands during that time. Furthermore, the total number of outdoor horticulture farms and the number of products produced on outdoor horticulture farms in the Netherlands including flower bulbs and tubers, tree nurseries and perennials, apples and pears were displayed from 2010 to 2022 and were sourced from StatLine.

Fertiliser price in the United Kingdom was obtained from the Agriculture and Horticulture Development Board (AHDB) and was available for some fertilisers used in the UK during July 2021, June 2022 and July 2022 in pound sterling. The availability of the data facilitated it to be assessed between two years and also on a smaller time scale between two months for a more in-depth comparison. For analysis, the data were converted to euros using the conversion rate of  $\pounds 1 = \pounds 1.18$  on the 15<sup>th</sup> of August 2022.

## 2.2 Fertiliser Sales in NWE

North-West Europe fertiliser sales data for NPK were obtained from the statistical office of the European Union, Eurostat (see Table 1). The data is available from the year 2008 to 2019 and are displayed per '000 t, to assess how the fertiliser sales in NWE had fluctuated annually.

## 2.3 Fertiliser Use

The data for fertiliser use in NWE were obtained from Eurostat, as N and P input (see Table 1). The data was available from 2010 to 2019 in most cases, but in some instances, it was not available for all years, such as for Luxembourg which was only available between 2010 and 2014. The data was displayed in kilogrammes per hectare (kg/ha). This data gives a clear indication as to how much N and P fertiliser is applied in NWE during that period.

## 2.4 Land Use in NWE

The land use data were obtained from Eurostat for the seven target countries across NWE, which are Belgium, France, Germany, Ireland, Luxembourg, the Netherlands and the United



Kingdom at a NUTS 2 level (see Table 1). The land use data were used to assess the land used for the agricultural and horticulture sector. The land use for the agriculture sector was available from 2009 to 2018. The land use data for Ireland at a NUT2 level was only available for 2018. The Utilised Agricultural Area (UAA) was available for indoor, outdoor, other, vineyards and specialist and citrus fruit farms from 2007 to 2016, in hectares (ha).

Further information was available on Statbel for Belgium regarding the area of land used by greenhouse companies and for horticulture holdings for indoor and outdoor horticulture in hectares (ha) over the years 2019 to 2021.

## 2.5 Horticulture Farms and Standard Output

The data were obtained from Eurostat for the number of horticulture farms in NWE that were involved with indoor, outdoor, other, vineyards and specialist and citrus fruit farms from 2007 to 2016 at a NUTS 2 level (see Table 1). Data was sourced from Eurostat for the standard output of horticulture farms in NWE that were involved with indoor, outdoor, other, vineyards and specialist and citrus fruit farms from 2007 to 2016 at a NUTS 2 level, which was recorded in euros.

The Netherlands' additional outdoor horticulture (Figures 9.6g and Figure 9.9) data was obtained from StatLine (2022). The statistics available included the total number of farms in outdoor horticulture and the number of farms that produce flower bulbs and tubers, tree nurseries and perennials, apples and pears. In addition, the data available for the area (ha) of land used to produce flower bulbs and tubers, cut flowers, tree nurseries and perennials, horticulture vegetables and endives were also recorded between the years 2010 and 2022.

# **3 Global Fertiliser Availability and Demand**

## 3.1 Global Fertiliser Price

Globally the price of fertilisers is rapidly increasing since 2021, with an expected surge in price in 2022 due to the Russia-Ukraine war, an increase that hasn't been observed since 2008. The price of fertiliser in 2008 soared due to a global food and energy crisis, where supply could not keep up with the demand, particularly in Asia. Furthermore, there was a huge demand for fertilisers in the United States, Brazil, and Europe for biofuel production (CSO, 2022b).

In addition, the production of livestock increased, thus increasing the demand for grain and subsequently for fertilisers. At that time, energy prices peaked, resulting in an increase in the price of natural gas, which is essential for N fertiliser production. The demand for sulphur increased and because adding sulphur to P increases its plant availability (Stanisławska-Glubiak, 2014) the price of phosphate increased which is necessary for the production of the world's most commonly used fertiliser DAP and other types of phosphate fertilisers. Also, the supply of good-quality phosphate rock diminished (CSO, 2022b). Currently, fertiliser inputs have become much more expensive. The European statistical office Eurostat has calculated



that the costs of agricultural goods and services rose by 27% in the first quarter of 2022 compared to the first quarter of the previous year.

The peak in fertiliser price is evident in Figure 3.1, which displays the global fertiliser prices (euro/t) for urea (containing 46% N; Figure 3.1A), DAP (containing 49% P; Figure 3.1B) and potassium chloride (containing 50% K; Figure 3.1C) over the past 13 years. During this time, the price of fertiliser increased with N costing 456 euros/t, P priced at 762 euros/t and K costing 403 euros/t in 2008, increasing to 527 euros/t in 2009.



Figure 3.1: Global fertiliser prices of urea, diammonium phosphate (DAP) and potassium chloride between the years 2008-2021 (Source: World Bank, 2022). Displayed as euros/tonne.

This increased price in 2021 is due to reduced supplies caused by a China export ban, Covid-19 and disruptions to the supply chain. The price of the raw materials component used in fertilisers, including ammonia, nitrogen, potash, urea, phosphates, sulphates, and nitrates, has risen 30% since the beginning of 2022 due to the Russia-Ukraine War (Eurostat, 2021). The increase in fertiliser price is evident in Figure 3.1, where the price of urea globally increased by 107% and DAP increased by 90% between 2020 and 2021, however, the price of potassium chloride did not increase in this period. The data presented in Figure 3.1, however, does not reflect the price increases of the current fertiliser market due to the sanctions imposed on Russia, as the official statistics are not keeping up with the reality of the situation or are not yet publically available.

### 3.2 Fertiliser Sales NWE

After the unprecedented peak in fertiliser prices in 2008, which continued into 2010 for N and K, the sale of fertilisers across NWE decreased. The mean sale of N decreased by 6% between 2010 and 2012 (Figure 3.2A). However, N sales increased between 2012 and 2014



by 7%. Since 2014, the sales of N have plateaued between 2015 and 2017, with a marked decrease in 2019, 12% lower than the N sales in 2014.

With regards to P, the mean sales decreased between 2011 and 2012 by 13%, with a slight increase in sales evident between 2012 and 2013 by 5% (Figure 3.2B). Since then P sales have gradually plateaued and decreased by 15%. Potassium sales decreased between 2010 and 2011 by 9%, with an increase in sales by 8% evident between 2011 and 2013 (Figure 3.2C). However, between 2013 and 2019, K sales plateaued with a slight decrease of 4%.



*Figure 3.2: Fertiliser sales of NPK in NWE between 2008 and 2019 (Source: Eurostat, 2021c). Displayed per '000 tonne.* 

According to PhosAgro (2012), one of the world's leading phosphate-based fertiliser producers they were able to increase their sales of fertilisers in containers, increasing their global customer market. In addition, in Ireland from 2013 to 2014, fertiliser demand increased due to a national fodder shortage (Eurostat, 2021b). With an increase in the global population, the growing demand for fertilisers is expected to increase (Agriland, 2022). In particular, more recently the Russia-Ukraine war and Covid-19 affected supply chains, which will ultimately drive the market demand. Currently and in the future, regulatory and environmental constraints coupled with high production costs are likely to act as drawbacks in the industry.

### 3.3 Land Use in NWE

Agricultural land accounted for 39% of the total area in the EU in 2018 (Eurostat, 2021b). In terms of promoting RDF use in agriculture, there has been in-depth research into what farmers are looking for in these recycled products regarding the RDF properties (Egan et al., 2022). However, to increase their use and the market demand for these sustainable fertilisers, it was important to explore other sectors, including horticulture.



According to the European Parliament report (European Parliament, 2014), the fruit and vegetable sector represents 18% of the total value of agricultural production in the EU, but only uses 3% of the EU's cultivated land. A report conducted by the European Parliamentary Research Service (EPRS) assessed the share of EU farms that specialised in horticultural products and their agricultural area by farm size in hectares in 2016 (Rossi, 2019). They found that 77% of the farmers in the EU cultivated an area of fewer than five hectares and grew crops that could be classified as horticulture, which represented just 19% of the total area cropped with horticulture products.

### 3.4 Fertiliser Use in NWE

According to Fertilisers Europe, of the 179m hectares of agricultural land available in the EU, 75% are fertilised with mineral fertilisers. The European Commission (2019b), states that the EU market value of fertilisers has been increasing annually by 3% since 2005. The quantity of fertilisers used in the EU represents 10% of the total use at a global level. In terms of volume, N is the most used nutrient in the EU, representing more than two-thirds of the total use of NPK. Fertiliser use between 2010 and 2019 in NWE varied per country.



Figure 3.3: Mean fertiliser input of N and P in NWE between 2010 and 2019 (Source: Eurostat, 2022a). Displayed in kg per hectare.

It is clear in Figures 3.3A and B that the Netherlands and Belgium are the dominant users of N and P, with a mean N input of 375kg/ha and 312kg/ha applied respectively. That is a 55% increase in N use in the Netherlands and a 29% increase in use in Belgium compared to the mean NWE value over that period. The Netherlands and Belgium were the highest users of P with a mean input of 35kg/ha and 32kg/ha applied respectively. That is, a 41% and a 30% increase compared to the mean NWE input of P respectively. In addition, Luxembourg was the third-highest county to apply N with a mean input of 250kg/ha, whereas the UK are the third-highest applicant of P with 24kg/ha.

## 3.5 RDF Demand in the Horticulture Sector

Fertilisers play a significant role not only in food security but also in securing the horticulture sector. The EU is dependent on importing 30% inorganic N, 68% phosphates and 85% potash (EC, 2022). Furthermore, the price of N products increased by 149% for EU farmers in September 2022, compared to the previous year (EC, 2022). This was due to the lack of



availability of natural gas (EC, 2022) caused by the Russian-Ukraine war. On average, 6% of input costs are attributed to purchasing fertilisers according to the European Commission (2022).

Although the EU's Farm to Fork strategy aims to reduce nutrient losses by 50% by 2030 while preserving soil fertility, the increased fertiliser prices have led to lower quantities of fertiliser being used in the agriculture and horticulture sectors (EC, 2022). As a result, it is expected to affect crop yields and food availability (EC, 2022). The European Commission (2022) have devised a list of best practices to support farmers to optimise their fertiliser use and reduce their dependency on imported fertiliser. Included in the recommendations are sustainable farming practices and training and increasing the use of organic fertilisers, including substitution, where possible, of mineral fertilisers by organic fertilisers to reduce the EU's dependence on gas.

The horticulture sector in Europe is thriving. Horticulture in the EU is a major contributor to the economy as it produces a wide range of fruit, berries, nuts and ornamental plants. According to Eurostat (2022f), an estimated 36.4mt of fruit were harvested in 2021. Furthermore, the EU's harvested production of fresh vegetables was 67.2mt in 2021, about 4.0 million tonnes more than in 2020. The EU is a major contributor to the world's wine market, in 2020, it accounted for 64% of the global production and 45 % of the wine-growing areas in the world (Eurostat, 2022f). In addition, the EU is the largest producer of olive oil in the world, accounting for around two-thirds of global production (Eurostat, 2022f).

Taking into account Europe's reliance on importing fertilisers, and the European Commission's efforts to work with farmers to strive towards more independence from mineral fertiliser use. They aim to guide them towards using more sustainable options such as RDFs. The fact that horticulture production in the EU is so important to the global economy it can be determined that there is an excellent opportunity for RDF use in the horticulture sector.

# 4 Belgium

## 4.1 Fertiliser Price

As with global fertiliser prices, the price of fertiliser in Belgium varied between 2015 and 2020. Urea cost 491 euro/t in 2015, increasing by 29% to 633 euro/t by 2020 (Figure 4.1; Statbel, 2022). Superphosphate price decreased between the years 2015 and 2016 by 44%, however, the price increased gradually between 2016 and 2019. By 2020, the price of superphosphate had decreased by 23% from 2019 to 2020 to 478 euro/t. Similarly, the price of potassium chloride remained consistent between 2015 and 2018, however it decreased between 2018 and 2020 by 14% to 235 euro/t.





Figure 4.1. Fertiliser prices in Belgium of urea, superphosphate and potassium chloride from the years 2015-2020 (Source: Statbel, 2022). Displayed in euros/tonne.

In 2020 potassium sulphate was the most expensive fertiliser to purchase in Belgium, costing 849 euros/t, followed by ammonium nitrate at 726 euros/t and sodium nitrate at 646 euros/t (Figure 4.2; Wageningen University, 2022). On the other hand, in 2020 potassium chloride was the cheapest fertiliser for sale at 235 euro/t. Delays in fertiliser availability across Europe caused by supply chain issues due to Covid-19 in 2019 and into 2020 drove the cost of fertiliser up during that time and account for the increase in fertiliser price in Belgium.



Cost of Fertiliser in Belgium in 2020

Fertiliser Type

Figure 4.2: Price of fertiliser in Belgium in 2020 (Source: Wageningen University, 2022). Displayed in euros/tonne.



## 4.2 Fertiliser Sales

In 2021, Belgium farmers were paying between 150 euros and 200 euros/t for fertiliser. By March 2022 it was costing them 800 euros/t (Lory, 2022). The sale of NPK fertilisers increased rapidly between 2008 and 2010 in the Belgo-Luxembourg Economic Union (Figure 4.3 A-C). Not only do farmers in Belgium have to manage rising prices of fertilisers, but there is also a lack of availability of them (Lory, 2022). The data presented in Figure 4.3 is a combination of fertiliser sales in both Belgium and Luxembourg. The data was not available for these two countries individually.

The sale of N remained relatively stable at between 180,000 – 190,000tpa from 2010-2019 (Figure 4.3A; Eurostat, 2021). In 2019, 189,000t of N was sold, similar to the quantities sold in 2014/2015. Phosphorous sales in the Belgo-Luxembourg Economic Union reached a maximum in 2010 (Figure 4.3B; Eurostat, 2021c). Sales of P had dropped since then with sales plateauing since 2014 at between 8,000-9,000t/year (Figure 4.3C; Eurostat, 2021c). In 2019, approximately 8,800t of P was sold in the Belgo-Luxembourg Economic Union. Similar to P sales, the sale of K plateaued from 2010 to 2013, after with the sales decreased by 20% in 2014. In 2019, 51,000t of K was sold in the Belgo-Luxembourg Economic Union.



Figure 4.3: Fertiliser sales of N, P and K in Belgo-Luxembourg Economic Union between 2008 and 2019 (Source: Eurostat, 2021c). Displayed in '000 tonne.

## 4.3 Fertiliser Use

Fertiliser use data (fertiliser input) was only available up to 2014 from Eurostat for Belgium. The use of fertiliser in Belgium decreased between 2011 and 2014 by 1.5% (Figure 4.4; 2022a), with 309kg/ha used in 2014. On the other hand, the use of P remained the same between 2010 and 2012 at 32kg/ha, however, in 2013 this increased to 33kg/ha. The lack of available data from 2014 limits the knowledge of current fertiliser practices and the potential use of RDFs.



*Figure 4.4: Fertiliser input of N and P in Belgium between 2010 and 2014 (Source: Eurostat, 2022a). Displayed in kg per hectare.* 

## 4.4 Agricultural Land Use

Agricultural lands account for 44% of the land area of Belgium (Statbel, 2021) and farmland is becoming increasingly concentrated. According to Access to Land, a European network of grassroots organisations securing land for agroecological farming, in the past 37 years, the average UAA per farm holding has more than tripled in Flanders and Wallonia (Statbel, 2021). The increase in the intensity of farm holdings is most significant for livestock farms with the average number of livestock per pig farm increasing from 141 animals in 1982 to the present average of 1414 animals (OECD, 2020). The largest land area used for agriculture is in the Prov. Hainaut region, which has decreased slightly between 2012 and 2018, however in 2018, 231,000ha of land was used for agriculture in the region (Figure 4.5; Eurostat, 2021b). Prov. West-Vlaanderen region had the second largest land area for agriculture with 214,000ha in 2018.



Figure 4.5: Land use for the agriculture sector in the NUTS 2 regions in Belgium from 2009 to 2018 (Source: Eurostat, 2021b). The top six regions with the largest land used in the agriculture sector are displayed as '000 hectares.



## 4.5 Horticulture in Belgium

Up to 22% of all agricultural production can be classified as horticulture in Belgium (ISHS). Horticulture in Belgium is an intensive form of farming with 49% of the sector associated with vegetable production, 20% fruit and 31% ornamentals (ISHS). Vegetables are grown both in the open and under glass, with chicory, peas, bean and leek some of the most important crops for direct consumption, whereas apples and pears are the main fruits grown in Belgium. Potted plants and arboriculture represent the largest sector of ornamentals, with Belgium being the largest producer of evergreen azaleas in the world, with up to 55m azaleas grown per year (ISHS) and a net worth of 36m euros in exports.

### 4.5.1 Horticulture Farms

In 2007, the largest number of horticulture farms practised indoor horticulture, with 2220 indoor farms recorded (Figure 4.6A; Eurostat, 2022b). However, this number decreased by 58% by 2016. The highest number of horticulture farms in Belgium are in indoor horticulture with 940 recorded in 2016, followed by specialist/citrus fruit with 870 farms recorded.

The number of indoor horticulture farms in Belgium has decreased in many regions since 2007, with the highest number of farms present in Prov. Antwerpen with 320 farms in 2016 (Figure 4.6B; Eurostat, 2022b). The number of outdoor farms in Belgium increased in Prov. Antwerpen and Prov. Oost-Vlaanderen regions 160 and 140 farms in 2013 to 200 and 170 farms in 2016, respectively (Figure 4.6C; Eurostat, 2022b). However, the highest number of outdoor horticulture farms was in Prov. West-Vlaanderen, with 210 farms in 2016. Other types of horticulture farms have decreased significantly, particularly in Prov. Oost-Vlaanderen, which has decreased by 83% from 400 farms in 2007 to just 70 farms in 2016 (Figure 4.6D; Eurostat, 2022b). The largest number of other types of horticulture farms is in Prov. West-Vlaanderen with 110 farms recorded in 2016. The highest number of specialist or fruit farms in Belgium is found in Prov. Limburg (BE), although they too have decreased by 40%, from 730 in 2007 farms to 440 farms in 2016 (Figure 4.6E; Eurostat, 2022b).

# North-West Europe ReNu2Farm



2007 2010 2013 2016

Figure 4.6: Number of (A) overall farms in the horticulture sector (B) indoor, (C) outdoor, (D) other and (E) specialist and citrus fruit farms in Belgium (Source: Eurostat, 2022b). Graphs B-E display the regions with the highest number of farms in Belgium.

### 4.5.2 Agricultural Area used for Horticulture

The number of indoor horticulture farms has decreased dramatically between 2007 and 2016 (Figure 4.6), however, in Figure 4.7, the area of land used for indoor horticulture has remained relatively stable. This suggests that the horticulture farm sizes in this sector are increasing an intensifying.

The largest UAA used for horticulture in Belgium is assigned to growing specialist/citrus fruit with 19,390ha of land used in 2016, a 12% increase from 2013 (Figure 4.7A; Eurostat, 2022b). This was followed by outdoor horticulture which decreased by 29% between 2013 and 2016. The land used for indoor horticulture increased in both Prov. Antwerpen and Prov. West-Vlaanderen by 28% and 74% between 2013 and 2016 respectively (Figure 4.7B; Eurostat, 2022b), with1,980ha of land used for indoor horticulture in Prov. West-Vlaanderen in 2016.





Figure 4.7: Utilised agricultural area for (A) the overall horticulture sector (B) indoor, (C) outdoor, (D) other and (E) specialist and citrus fruit farms in Belgium (Source: Eurostat, 2022b). Displayed in hectares. Graphs B-E display the regions with the largest land area used for horticulture in Belgium displayed in hectares.

Land used for outdoor horticulture in Prov. West-Vlaanderen was the highest in Belgium in 2010, however, this decreased by 49% between 2010 and 2016 (Figure 4.7C; Eurostat, 2022b). In 2016, the largest land used for outdoor horticulture was in Prov. Antwerpen with 3160 ha.

Agricultural area utilised for other types of horticulture was greatest in Prov. Oost-Vlaanderen between 2007 and 2013, however, this decreased by 58% by 2016 (Figure 4.7D; Eurostat, 2022b). In 2016, Prov. West-Vlaanderen had the largest land area with 1,530ha. Prov. Limburg (BE) has the largest land area used for specialist or citrus fruit in Belgium, which has increased by 16% between 2013 and 2016 with 10,600ha of land used in 2016 (Figure 4.7E; Eurostat, 2022b).





*Figure 4.8: Land used by greenhouse companies and for horticulture holdings in Belgium (Source: Statbel, 2022). Displayed in hectares.* 

Furthermore, the land used by greenhouse companies and for indoor and outdoor horticultural holdings is displayed in Figure 4.8 (Statbel, 2022). Overall, the area of land used for these types of horticulture has increased from 2019 to 2021. The largest amount of land was used for outdoor vegetable holdings, including non-perennial fruit crops, with 2,708 ha recorded in 2021. There was 720 ha of land used for companies with greenhouse crops in Belgium in 2021 and 367 ha used by companies with fresh vegetables in greenhouses in the same year. In addition, 243 ha of land were used for outdoor strawberry holdings and 210 ha were used for holdings with greenhouse fruit crops in 2021, respectively.

### 4.5.3 Horticulture Output

Overall, 22% of agriculture in Belgium is horticulture (ISHS). Indoor horticulture had a standard output of 598m euros in 2016 a 32% increase from the output in 2010 the largest contributor in the horticulture sector to the Belgium economy (Figure 4.9A; Eurostat, 2022b). The output for indoor horticulture per NUTS 2 regions in Figure 4.9B was the highest in Prov. Antwerpen overall, with an output of 237m euros in 2016 (Figure 4.9B; Eurostat, 2022b). Prov. West-Vlaanderen output for outdoor horticulture was 135,000,000 in 2013, however, this decreased by 71% to 39m euros by 2016 (Figure 4.9C; Eurostat, 2022b).





Figure 4.9: Standard output for (A) the overall horticulture sector (B) indoor, (C) outdoor, (D) other and (E) specialist and citrus fruit farms in Belgium (Source: Eurostat, 2022b). Graphs B-E display the regions with the largest output for horticulture in Belgium displayed in '000,000 euros.

In 2016, the standard output for outdoor horticulture was highest in Prov. Antwerpen with 56m euro. Other horticulture in Prov. Oost-Vlaanderen was worth 107m euros in 2007, however, this decreased by 76% by 2016 (Figure 4.9D; Eurostat, 2022b). The output for other horticulture in Belgium is now greater in Prov. West-Vlaanderen, which is worth 39m euros. Specialist and citrus fruit standard output is greatest in Prov. Limburg (BE) woth166m euros to the Belgium economy in 2016 (Figure 4.9E; Eurostat, 2022b).





■ 2016 ■ 2017 ■ 2018 ■ 2019 ■ 2020 ■ 2021 forecasts

Figure 4.10: Economic accounts for horticulture in Belgium (millions of euros; Source Statbel, 2022).

In addition, in Figure 4.10, which describes the economic accounts for horticulture in Belgium, vegetables and horticultural products generate the most money for the economy, with 1683.7m euros predicted in 2021(Statbel, 2022). Of that, fresh vegetables produced 1122.5m euros, sales of plants and flowers earned 561.2m euros and fruit production produced 666.4m euros in 2021.

## 4.6 Chapter Summary

Up to 22% of all agricultural production can be classified as horticulture in Belgium (ISHS). In 2021, Belgium farmers were paying between 150 euros and 200 euros/t for fertiliser. By March 2022 it was costing them 800 euros/t (Lory, 2022). Not only do they have to deal with the surging prices of fertilisers, but there is also a lack of availability (Lory, 2022). In 2020, potassium sulphate, ammonium nitrate and sodium nitrate were the most expensive fertilisers in Belgium, however, in recent years due to sanctions placed on Russia by the West, the demand for N, P and K have increased (Lory 2022).

The largest number of horticulture farms practised indoor horticulture, however, most horticulture land (ha) is used for outdoor vegetable holdings. On the other hand, the largest area farmed indoor is used for growing fresh vegetables in greenhouses. The area of land used by greenhouse companies and for horticulture holdings is steadily increasing. It is estimated that indoor horticulture had a standard output of 598m euros in 2016, a 32% increase from the output in 2010. Indoor horticulture is the largest contributor in the horticulture sector to the Belgian economy, with fresh vegetables contributing the highest output (euros) to the Belgium economy in 2021. In July 2022, output prices of edible horticultural products decreased compared to the previous year. Overall, compared to July 2021, the vegetable index decreased by 9.2% and the fruit index fell by 27.5% (Statbel, 2022).

Belgium is one of the largest European exporters of trees, plants and flowers in Europe. Belgian horticulture is known for its variety and quality of ornamental plants with 90% of Europe's production of azaleas and chrysanthemums occurring in Flanders (VLAM, 2022). In addition, Belgium's ornamental horticulture production value has risen in recent years to 592m



euros in 2019, an increase of 8.4% compared to 5 years earlier (VLAM, 2022). The total export value of ornamental plants in Belgium is 568m euros, placing Belgium among the top 5 floriculture exporters in Europe and within the top 10 in the world (VLAM, 2022).

Overall, there is a thriving horticulture industry in Belgium, they import significant quantities of fertilisers and therefore there is a potential demand for RDF products, especially in the ornamental flowers sector.

# **5** France

## 5.1 Fertiliser Price

The price of fertilisers in France increased in 2021 and continued to do so considerably into 2022 (Figures 5.1 and 5.2). A farmer in France stated that fertiliser prices have more than trebled during 2021, (France 24, 2021). According to Figure 5.1, the price of ammonium nitrate 33.5%N and 27%N increased steadily from August 2020 to September 2021 (ARVALIS - Institut du vegetal, 2022). However, from October 2021 to April 2022, ammonium nitrate 33.5%N increased by 33% to 3124 euro/t and 27%N increased by 56% to 3455 euro/t (ARVALIS - Institut du vegetal, 2022). The price of urea increased steadily from January to September 2021, where it increased by 96% by December 2021 to 2,182 euro/t (ARVALIS - Institut du vegetal, 2022). The price of urea decreased between December 2021 and February 2022 to 1,648 euro/t, after which it rapidly increased by 66% in April 2022 to 2,731 euro/t (ARVALIS - Institut du vegetal, 2022).



### Cost of N Fertilisers in France 2020-2022

*Figure 5.1. Monthly fertiliser price of nitrogen-based fertilisers in France from August 2020 to April 2022 (Source: ARVALIS - Institut du vegetal, 2022). Displayed as euros per tonne.* 





### Cost of K & P Fertilisers in France 2020-2022

Figure 5.2. Monthly fertiliser price of potassium and phosphorous based fertilisers in France from August 2020 to April 2022 (Source: ARVALIS - Institut du vegetal, 2022). Displayed as euros per tonne.

The price of potassium chloride gradually increased by 226% in France throughout 2021 and into 2022, costing 1,539 euro/t in April 2022 (Figure 5.2; ARVALIS - Institut du vegetal, 2022). Likewise, the price of TSP increased gradually between January and August 2021. Between September 2021 and April 2022, the price of TSP increased by 112% (ARVALIS - Institut du vegetal, 2022). Similarly, the price of DAP increased gradually from August 2020 to September 2021, where it increased by 72% from October 2021 to April 2022 (ARVALIS - Institut du vegetal, 2022).



*Figure 5.3: Price of nitrogen based fertilisers in France between 2008 and 2022 (Source: ARVALIS - Institut du vegetal, 2022). Displayed in euros per tonne.* 





Price of K & P Fertilisers in France

*Figure 5.4: Price of potassium and phosphorous based fertilisers in France between 2008 and 2022 (Source: ARVALIS - Institut du vegetal, 2022). Displayed in euros per tonne.* 

Figures 5.3 and 5.4 (ARVALIS - Institut du vegetal, 2022) display the average price of fertilisers in France from the year 2008 to 2022 (first four months of the year) highlighting the fluctuations in fertiliser prices. However, the price of fertiliser in 2022 increased the most for each fertiliser displayed. In particular, the price of ammonium nitrate (27%N) increased by 102% from 1495 euro/t to 3021 euro/t and ammonium nitrate (33.5%N) increased by 100% from 1516 euro/t to 3029 euro/t between 2021 and 2022 (ARVALIS - Institut du vegetal, 2022). Furthermore, potassium chloride and urea increased by 78% from 593 euro/t to 1056 euro/t and 1204 euro/t to 2143 euro/t in the same year (ARVALIS - Institut du vegetal, 2022).

## 5.2 Fertiliser Sales in France

Fertiliser sales in France, in general, have been declining, according to the 'Union des Industries de la Fertilisation' (UNIFA), shipments of mineral and organo-mineral fertilisers reached a total of only 8.7m tonnes during 2018-2019, this was a decrease in sales by 4% compared to the previous years (WillAgri, 2019). In addition, the sales of basic mineral fertilisers were down to 2.3m tonnes or a 6% decrease during the same period. This trend is evident in Figure 5.5A where the sale of N decreased from 2,243,000t to 2,031,000t, or by 9% between 2017 and 2019 (Eurostat, 2021c). Likewise, the sale of P continued to decrease between 2012 and 2019, albeit with slight fluctuation through the years, from 213,000t to 172,000t, or by 20% (Figure 5.5B; Eurostat, 2021c). On the other hand, the sales of K increased slightly between 2016 and 2019, from 354,000t to 390,000t or 10% (Figure 5.5C; Eurostat, 2021c) with sales starting to stabilise in 2019.





Figure 5.5: Fertiliser sales of N, P and K in France between 2008 and 2019 (Source: Eurostat, 2021c). Displayed in '000 tonnes.

### 5.3 Fertiliser Use

The overall use of N and P in France had decreased in recent years. The use of N fertiliser increased by 5% to 161kg/ha in 2011, however, this decreased again by 6% to 151kg/ha in 2012 (Figure 5.6A; Eurostat, 2022a). Following this, the use of N increased between 2012 and 2014 by 5% from 151kg/ha to 159kg/ha. After which the use of N continued to decrease by 6% between 2014 and 2019 to 149kg/ha. The use of P saw a 10% decrease in application rates between 2013 and 2019, however, in general, the levels have relatively plateaued in recent years with the level ranging from 19.5kg/ha to 17.6kg/ha (Figure 5.6B; Eurostat, 2022a).



Figure 5.6: Fertiliser input of N and P in France between 2010 and 2019 (Source: Eurostat, 2022a). Displayed in kg per hectare.



## 5.4 Agricultural Land Use

In 2018, an estimated 53% of land in France was used for agriculture, the equivalent of 30m ha (Britannica, 2022). Of that 33% were arable, 14% were grassland and 2% were permanent crops including vines and orchards (Statista, 2019). Arable farming is most prevalent in the northern and western regions of France, centred on the Paris Basin. Permanent grassland is common in upland and mountainous areas such as the Massif Central, the Alps, and the Vosges, although it is also common in the western région of Normandy. In addition, the Mediterranean regions are more focused on permanent crops (Britannica, 2022). The largest area of agricultural land use in France in 2015 was Centre (FR) with 2,471,000ha, however, the data was not available in 2018 for Centre (FR). According to Eurostat, in 2018 Midi-Pyrénées had the largest area of land used for agriculture, with 2,377,000ha available (Figure 5.7; Eurostat, 2021b).



**2**009 **2**012 **2**015 **2**018

Figure 5.7: Land use for the agriculture sector for the NUTS 2 regions in France from 2009 to 2018 (Source: Eurostat, 2021b). The top six regions with the largest land used in the agriculture sector in France are displayed as '000 hectares.

## 5.5 Horticulture in France

Horticulture in France, includes vines, fruits, and vegetables, however, France is most famous for its wines, more than any other country in the world. Viticulture and winemaking are concentrated principally in Languedoc-Roussillon and the Bordeaux area, but production also occurs in Provence, Alsace, and in the Rhône and Loire valleys, Poitou-Charentes, and the Champagne region (Britannica, 2022). Recently, there has been a noticeable decrease in the production of vin ordinaire, which can be contributed to EU policy that favours an increase in the output of quality wines (Britannica, 2022). Fruit production (mainly of apples, pears, and peaches) is largely concentrated in the Rhône and Garonne valleys and the Mediterranean region. Vegetables are also grown in the lower Rhône and Mediterranean areas, but a large part of output comes from western France (Brittany) and the southwest and the northern région of Hauts-de-France, where sugar beets and potatoes are produced (Britannica, 2022).



#### 5.5.1 Horticulture Farms

Overall, the number of horticulture farms in France is dominated by vineyards (Figure 5.8A; Eurostat, 2022b), with 64,650 vineyards recorded in 2016. Provence-Alpes-Côte d'Azur had the highest number of indoor horticulture farms recorded with 1,300 farms in 2016, 2% more than in 2013 (Figure 5.8B; Eurostat, 2022b). In 2013, Réunion had the highest number of outdoor horticulture farms with 1,400 recorded, however, that had decreased by 28% in 2016 (Figure 5.8C; Eurostat, 2022b). There were 1,060 outdoor horticulture farms in Provence-Alpes-Côte d'Azur in 2016.



Figure 5.8: Number of (A) overall farms in the horticulture sector (B) indoor, (C) outdoor, (D) other, (E) vineyard, and (F) specialist and citrus fruit farms in France (Source: Eurostat, 2022b). Graphs B-F displays the regions with the highest number of farms in France.

The highest number of other types of horticulture farms in 2013 was also in Provence-Alpes-Côte d'Azur, with 850 farms recorded, however, this had decreased by 42% in 2016 to 490 farms (Figure 5.8D; Eurostat, 2022b). In 2016, the Rhône-Alpes had 600 other horticulture farms. Languedoc-Roussillon has the highest number of vineyards in France, with 16,440 vineyards in 2013, increasing by 1% to 16,630 vineyards in 2016 (Figure 5.8E; Eurostat,



2022b). Whereas Rhône-Alpes have the highest number of fruit farms with 1,590 fruit farms in 2016, however, the number of fruit farms in that region had decreased considerably by 53% since 2007 (Figure 5.8F; Eurostat, 2022b).

### 5.5.2 Agricultural Area used for Horticulture

Overall, 1,083,030 ha of agricultural land was used for vineyards in France in 2016, with 181,110 ha used for specialist or citrus fruit in the same year (Figure 5.9A; Eurostat, 2022b). Indoor horticulture was the most prevalent in Aquitaine, with 9,680 ha used in 2013 increasing by 36% to 13,130 ha in 2016 (Figure 5.9B; Eurostat, 2022b). However, indoor horticulture has taken off in the Midi-Pyrénées in recent years, with 1,040 ha used for it in 2013, increasing by 520% to 6,450 ha in 2016. Outdoor horticulture was the most prevalent in Aquitaine in 2013, with 11,420 ha used for this type of horticulture, however, by 2016 the land used for it had decreased by 35% (Figure 5.9C; Eurostat, 2022b). In 2016, the land used for outdoor horticulture was highest in Pays de la Loire, with 7,550 ha available.

The land used for other types of horticulture was also prevalent in Pays de la Loire with 9,410 ha utilised in 2016, which was a 41% increase from 2013 (Figure 5.9D; Eurostat, 2022b). The land used for vineyards was highest in the region of Languedoc-Roussillon in France with 262,070 ha of land used in 2016 (Figure 5.9E; Eurostat, 2022b). In 2007, the Rhône-Alpes had the highest area of land used for specialist or citrus fruit production with 54,990 ha available, however, this has decreased by 52% in 2016 (Figure 5.9F; Eurostat, 2022b). On the other hand, in 2016 the land used for specialist citrus fruit was the highest in the Aquitaine region with 33,040 ha available. The highest number of farms in Figure 5.8 does not directly correlate with the area of land use in France (Figure 5.9). In many cases, the NUTS 2 regions where there are more farms for example indoor horticulture in Provence-Alpes-Côte d'Azur, doesn't correspond with the largest land area used for indoor farming, which was in Aquitaine. This indicates that in some areas indoor farms are smaller (a large number of farms, with a small number of farmers) while in other areas there are fewer farms but the farms are bigger. Again the largest area of land used for outdoor horticulture in Pays de la Loire differed from the number of outdoor horticulture farms in Provence-Alpes-Côte d'Azur. This corresponds with French Farming, (2021) which states that France has lost up to 20% of their farms as large-scale agriculture is increasing.





Figure 5.9: Utilised agricultural area for (A) the overall horticulture sector (B) indoor, (C) outdoor, (D) other, (E) vineyard and (F) specialist and citrus fruit farms in France (Source: Eurostat, 2022b). Graphs B-F display the regions with the largest land area used for horticulture in France displayed in hectares.

### 5.5.3 Horticulture Output

Vineyards produce the highest horticultural output in France, worth 11,684m euros in 2016, up 14% from the 2013 census (Figure 5.10A; Eurostat, 2022b). Indoor horticulture was worth 389m euros in Bretagne in 2016, with a 369% increase from the 2013 output (Figure 5.10B; Eurostat, 2022b). Pays de la Loire had the highest outdoor horticulture output of 122m euros in 2016, however, this was down 43% from 2013 (Figure 5.10C; Eurostat, 2022b). Likewise, Pays de la Loire had the highest other horticulture output of 268m euros in 2016, which was down 39% from the 2013 output (Figure 5.10D; Eurostat, 2022b).

In 2016, the French region of Champagne-Ardenne had the highest output for vineyards with 2,523m euros in 2016, a 3% increase from the 2013 census (Figure 5.10E; Eurostat, 2022b). In addition, the output for vineyards in the region of Aquitaine was also high, with 2,186m euros recorded in 2016, this was a 20% increase from the outputs for 2013. Specialist or citrus fruit output was the highest in Provence-Alpes-Côte d'Azur in 2016, with 187m euros produced (Figure 5.10F; Eurostat, 2022b).





Figure 5.10: Standard output for (A) the overall horticulture sector (B) indoor, (C) outdoor, (D) other, (E) vineyard and (F) specialist and citrus fruit farms in France (Source: Eurostat, 2022b). Graphs B-F display the regions with the largest output for horticulture in France displayed in '000,000 euros.

## 5.6 Chapter Summary

France is the EU's leading agricultural nation, accounting for more than one-fifth of the total value of output, and is responsible for more than one-third of the EU's production of wine (Britannica, 2022). Therefore, fertilisers are essential for agriculture in France, however, the price of fertilisers in France has increased since 2021 and continues to do so into 2022, with one farmer stating that fertiliser prices have more than trebled during 2021, incurring costs to farmers from between 300 euros and 350 euros per ha (France 24, 2021). This resulted in farmers deciding to limit the number of crops that need a lot of N (France 24, 2021).

In addition, fertiliser sales in France, in general, have been declining, with a decrease in organo-mineral fertiliser sales by 4% and the sales of basic mineral fertilisers were down by 6% in 2018-2019 compared to the previous years. This supports the findings in this report that the overall use of N and P in France had decreased in recent years, particularly since 2018.



Additionally, France plans to increase agronomic recycling of organic matter as part of its circular economy roadmap, and national regulatory changes are being implemented to make this policy come into enforcement (Nutriman 2020).

Furthermore, horticulture in France is predominately focused on vines for wine production, for which it is most famous, more than any other country in the world. Viticulture and winemaking are concentrated mainly in the Languedoc-Roussillon region, with 16,630 vineyards reported in 2016. In addition, vineyards produce the highest horticultural output in France, worth 11,684m euros in 2016, up 14% from the 2013 census. With France being one of Europe's top producers of wine, the use and availability of fertilisers are of utmost importance to their economy. Therefore, there is excellent potential demand for the use of RDFs in France in the horticulture sector.

# 6 Germany

## 6.1 Fertiliser Price

Fertiliser prices in Germany decreased between 2015 and 2017, particularly in the case of calcium ammonia nitrate (CAN) and urea, which cost 206 euros/t and 290 euros/t in 2017, after which the prices remained relatively stable until 2019 (Figure 6.1; Chamber of Agriculture Germany). Between 2019 and 2020 the price of fertiliser decreased in Germany, with CAN costing just 200 euros/t and sulphate of ammonia costing 228 euros/t in 2020. However, in 2021 the cost of fertilisers skyrocketed with the price of urea increasing by 70% and ammonium sulphate nitrate increasing by 54%.



Price of Fertilisers in Germany

Figure 6.1. Fertiliser prices of calcium ammonia nitrate CAN, urea, sulphate of ammonia and ammonium sulphate nitrate in Germany from the years 2014-2021 (Source: Chamber of Agriculture Germany). Displayed as euros per tonne.



### 6.2 Fertiliser Sales

The general trend across Europe is that fertiliser sales are decreasing and this is reflected in the sales recorded in Germany. Sales of N in Germany decreased by 26% between 2014 and 2019, with 1,344,000t of N sold in Germany in 2019 (Figure 6.2A; Eurostat, 2021c). Phosphorous sales in Germany increased rapidly between 2012 and 2014, however, like N, the sales of P decreased by 30% between 2014 and 2019, with 92,000t of P sold in 2019 (Figure 6.2B; Eurostat, 2021c). Although there was an increase in K sales in Germany between 2018 and 2013, sales decreased between 2014 and 2015, where they plateaued between 2015 and 2019 (Figure 6.2C; Eurostat, 2021c). Just 343,000t of K were sold in Germany in 2019.



*Figure 6.2: Fertiliser sales of N, P and K in Germany between 2008 and 2019 (Source: Eurostat, 2021c). Figures are displayed in thousands of tonnes of fertiliser.* 

## 6.3 Fertiliser Use

Similar to N and P sales, the use of fertilisers in Germany has decreased, where N input was 222kg/ha in 2015, declining to 179kg/ha in 2019, which is a 19% decrease (Figure 6.3A; Eurostat, 2022a). Likewise, the use of P decreased by 22% between 2015 and 2019, with 18kg/ha of P used in 2019 (Figure 6.3B; Eurostat, 2022a).




*Figure 6.3: Fertiliser input of N and P in Germany between 2010 and 2019 (Source: Eurostat, 2022a). Figures are displayed in kg per hectare.* 

### 6.4 Agricultural Land Use

Germany is the third largest producer of agricultural goods in the European Union, following France and Italy (Climate Change Post, 2022). In 2004, it is estimated that over 372,400 farms were in operation in Germany, with up to 1.27m workers employed, either full or part-time in German agriculture (Climate Change Post, 2022). The regions of Brandenburg and Sachsen-Anhalt had the largest land use in agriculture in Germany, with 1,388,000 ha and 1,243,000 ha used respectively in 2018 (Figure 6.4; Eurostat, 2021b). The agricultural land use in Brandenburg increased by 1.5% and decreased by 1% in Sachsen-Anhalt between 2015 and 2018 respectively.



Figure 6.4 Land use for the agriculture sector in the NUTS 2 regions in Germany from 2009 and 2018 (Source: Eurostat, 2021b). The top six regions with the largest land used in the agriculture sector in Germany are displayed as '000 hectares.



### 6.5 Horticulture in Germany

There is a wide range of horticulture products produced in Germany, including vegetables, fruit, wine, bedding plants, balcony plants, potted plants, cut flowers and woody plants (Federal Ministry of Food, 2016). Ornamental horticulture in Germany produces on average 1.5b bedding, balcony, herbaceous and perennial plants a year, in addition to 270m houseplants. Furthermore, up to 24,000 ha of land is used to grow deciduous, wild, coniferous, fruit and forest groves (Federal Ministry of Food, 2016). However, apples remain by far the largest group of orchard fruit harvested in Germany. It is predicted there will be 1,051,000t of apples grown in 2022 (Statistisches Bundesamt, 2022a).

### 6.5.1 Horticulture Farms

Vineyard farms dominate the horticulture sector in Germany (Figure 6.5A; Eurostat, 2022b), with 12,900 farms recorded in the 2016 census. The number of indoor farms in Germany was the highest in the Düsseldorf region, however, this has gradually decreased from 740 farms in 2007 to 550 farms recorded in 2016, which is a reduction of 26% over nine years. (Figure 6.5B; Eurostat, 2022b).

Rheinhessen-Pfalz had the highest number of outdoor horticulture farms, with 160 farms recorded, 60% more outdoor horticulture farms than in 2013 (Figure 6.5C; Eurostat, 2022b). The number of other horticulture farms was the greatest in the region of Weser-Ems in Germany, with 270 farms recorded in 2016 (Figure 6.5D; Eurostat, 2022b), however, there was a 53% decrease in the number of other horticulture farms between 2007 and 2016 in this region.

The Rheinhessen-Pfalz region also had the highest number of vineyards recorded in 2016, with 4,200 vineyards, however, this was a 26% decrease from the 2007 census (Figure 6.5E; Eurostat, 2022b). In addition, the highest number of specialist or citrus fruit farms was in Freiburg, with 1,120 farms recorded in 2016 (Figure 6.5F; Eurostat, 2022b).





Figure 6.5: Number of (A) overall farms in the horticulture sector (B) indoor, (C) outdoor, (D) other, (E) vineyard and (F) specialist and citrus fruit farms in Germany (Source: Eurostat, 2022b). Graphs B-F displays the regions with the highest number of farms in Germany.

### 6.5.2 Agricultural Area used for Horticulture

According to the German statistics Destatis, winegrowers in Germany produced 8.45m hectolitres of wine and must in 2021. Therefore, Figure 6.6A correlates with that statement as the largest agricultural area in Germany was used for vineyards, with 117,280ha recorded in 2016, a 3% increase from the 2013 census (Eurostat, 2022b).

The largest land use for indoor horticulture was in Düsseldorf, with 2,170 ha used in 2016, a 53% increase from the 2013 census (Figure 6.6B; Eurostat, 2022b). The largest land area used for outdoor horticulture was dominated by the Rheinhessen-Pfalz region, which was recorded at 8,540 ha in 2013, increasing by 82% to 15,550 ha in 2016 (Figure 6.6C; Eurostat, 2022b).

Land used for other horticulture in Germany was predominately found in the Schleswig-Holstein and Weser-Ems regions, with 4,310 ha and 4,030 ha recorded in 2016, respectively



(Figure 6.6D; Eurostat, 2022b). Rheinhessen-Pfalz region in Germany had the highest land use for vineyards, with 63,220ha recorded in 2016, a 3% increase from 2013 land use (Figure 6.6E; Eurostat, 2022b). On the other hand, the Tübingen region had the largest land used for specialist or citrus fruit production, with 11,580ha recorded in 2016, a 17% increase from the 2013 recordings (Figure 6.6F; Eurostat, 2022b).



Figure 6.6: Utilised agricultural area for (A) the overall horticulture sector (B) indoor, (C) outdoor, (D) other, (E) vineyard and (F) specialist and citrus fruit farms in Germany (Source: Eurostat, 2022b). Graphs B-F display the regions with the largest land area used for horticulture in Germany, displayed in hectares.

### 6.5.3 Horticulture Output

Overall the standard output for Germany in the horticulture sector was greatest for indoor horticulture, worth 1,435m euros in 2016 (Figure 6.7A; Eurostat, 2022b). In particular indoor horticulture in Düsseldorf was worth 420m euros in 2016, 37% more than in 2013 (Figure 6.7B; Eurostat, 2022b). Outdoor horticulture in Rheinhessen-Pfalz was worth 561m euros in 2007,



decreasing to 140m euros in 2013 however, this increased in 2016 to 314m euros (Figure 6.7C; Eurostat, 2022b). Standard output for other types of horticulture was the greatest in the region of Weser-Ems in Germany, which was worth 172m euros in 2016, this was a decrease of 18% compared to 2013 (Figure 6.7D; Eurostat, 2022b).

Standard output for vineyards was the highest in Rheinhessen-Pfalz, which was worth 1,393m euros in 2007, however, this decreased by 56% by 2016 (Figure 6.7E; Eurostat, 2022b). The region of Lüneburg had the highest standard output in the specialist or citrus fruit sector, which was worth 141m euros in 2016, a 14% increase from the 2013 output (Figure 6.7F; Eurostat, 2022b). In addition, the standard output for the region of Tübingen was worth 130m euros in 2016.



Figure 6.7: Standard output for (A) the overall horticulture sector (B) indoor, (C) outdoor, (D) other, (E) vineyard and (F) specialist and citrus fruit farms in Germany (Source: Eurostat, 2022b). Graphs B-F display the regions with the largest output for horticulture in Germany displayed in '000,000 euros.



# 6.6 Chapter Summary

Fertiliser prices are increasing throughout Europe, including in Germany. In 2021 the cost of fertilisers in Germany skyrocketed with the price of urea increasing by 70% and ammonium sulphate nitrate increasing by 54% compared to the previous year. The increase in fertiliser prices occurred before the Russian-Ukraine war and could be attributed to supply chain issues due to Covid-19 and the China export ban. In general, fertiliser sales are decreasing in Europe and fertiliser sales in Germany are following that trend.

German wine production from a total of 103,400 ha of vineyards covers approximately 35% of the wine consumed in Germany (Statistisches Bundesamt, 2022b). There are only three countries in the world with wine markets that are larger than that of Germany, which include the US, France and Italy. Due to recent climate conditions, grape growing in Germany has been affected by heat waves, drought and dry soil conditions. However, winegrowers in Germany expect the grape harvest to be better in 2022 than in 2021, with estimated yields of 8.88m hectolitres of wine must, a 4.2% increase on 2021 figures (Statistisches Bundesamt, 2022b).

Due to the importance of wine production and horticulture in general to the German economy and the recent increases in fertiliser prices due to the Russian-Ukraine war, there is excellent potential for the use of RDFs. The demand for RDFs in Germany can be driven by the lack of availability of mineral fertilisers globally, rising fertiliser costs and the current energy crisis.

# 7 Ireland

# 7.1 Fertiliser Price

In Ireland, the price of fertiliser peaked in 2008 (Figure 7.1), with the price of urea costing 443 euros/t, and granular superphosphate containing 16% P priced at 507 euros/t in 2008, increasing to 644 euros/t by 2009 (CSO, 2022). There was no data available for the price of potassium chloride in Ireland in 2008. The subsequent years following the initial fertiliser price surge in 2008 resulted in a price drop (see Figure 7.1), where the price of urea in Ireland had decreased to 330 euros/t by 2010 (CSO, 2022). In addition, the price of potassium chloride decreased to 448 euros/t by 2010. This price reduction was due to the lack of demand as farmers were not willing to pay two or three times the price of fertiliser in early 2007. On the other hand in Ireland, the price of potassium chloride increased by 17% between the years 2020 and 2021 (Figure 7.1) and urea increased by 32% in Ireland at that time (CSO, 2022). It is evident at a regional level in Figure 7.1 that the increased price rates of different fertilisers follow the same trend.

In 2021, Sulphate of Potash (42% K) was the most expensive type of fertiliser for sale in Ireland at 600 euros/t, followed by Compound 7-6-17 which cost 528 euros/t and Compound 13-6-20 which cost 475 euros/t (Figure 7.2; CSO, 2022). On the other hand, calcium ammonium nitrate (27.5% N) was the least expensive fertiliser in Ireland in 2021 costing 319



euros/t. According to the CSO in Ireland, fertiliser prices increased by 178% in the first four months of 2022 (CSO 2022). In addition, the CSO (2022) also stated that the Agricultural Price Indices indicate that the cost of fertiliser in April 2022 increased by over 16% compared to Mach of the same year. This price increase can be attributed to the sanctions imposed by Europe on Russia due to the Russia-Ukraine war, affecting the supply chain of fertilisers.



Figure 7.1. Fertiliser prices of urea, superphosphate and potassium chloride in Ireland between the years 2008-2021 (Source: CSO, 2022). Displayed as euros per tonne.



Fertiliser Type

Figure 7.2: Price of different fertiliser types in Ireland in 2021 (Source: CSO, 2022). Displayed as euros per tonne.



# 7.2 Fertiliser Sales

The sale of NPK in Ireland has continued to increase since 2008, although fluctuating through the years 2009-2019. A recent report from the CSO (2022c) suggested that total fertiliser sales increased by 6% in Ireland in 2021 to 1.7 mt. The N content of fertilisers sold in 2021 was 5% higher than in 2020 at 399,164 t. The P and K content of fertilisers sold in 2021 was up 4% in 2020 at 46,068 t and 122,922 t respectively. The sale of lime sales increased by 50% in 2021 to 1.3 mt.



Figure 7.3: Fertiliser sales of N, P and K in Ireland between 2008 and 2019 (Source: Eurostat, 2021c). Displayed in '000 tonne.

The fertiliser sales trend in Ireland differs from its European counterparts, which is evidently in decline. It is evident in Figure 7.3 that fertiliser sales soared in the year 2017, particularly the sale of N (Eurostat, 2021c). It was predicted by farmers in 2016 that due to low fertiliser costs that year, fertiliser sales would increase, due to farmers forward buying fertiliser. Subsequently, fertiliser prices increased by 6% between 2017 and 2018 (CSO, 2019). In addition, the long winter period from late 2017 to early 2018 and an increase in fertiliser prices in 2018 are linked to a slower rate of fertiliser sales in 2018 (O'Brien, 2018). The increase in fertiliser sales in Ireland could also be attributed to increased livestock numbers. Brock et al. (2022) observed an increase in cattle numbers in the Irish dairy sector, by 3.5% from 1.95m in 2015 to 2.02m animals in 2019. According to the EPA (2022b), the number of dairy cows increased by 2.8%, in 2021 from 2020.



# 7.3 Fertiliser Use

The Irish Government aims to reduce N fertiliser use on Irish farms from a high of 408,000t in 2018 to 325,000t by 2030 (Moran 2021). The National Farm Survey was a long-term study from the years 2005-2015 which focused on the use of NPK and lime on farms in Ireland. The results suggested that NPK application rates on grassland were 11-16% higher at the beginning of the study, compared to the end of the study, with up to a 52% decrease in fertiliser application halfway through the study (Dillon et al., 2015).

However, since the National Farm Survey ended in 2015, the use of fertiliser (N and P) has steadily increased (Figure 7.4). This data correlates with fertiliser sales in Ireland (Figure 7.3). However, there was a 7% decrease in N use in 2011 from the previous year (Figure 7.4; Eurostat, 2022a). In addition, N uses spiked in 2013 with 206.8kg/ha being utilised compared to 190.3kg/ha in the previous year (Eurostat, 2022a). By the year 2017, the application of N in Ireland had increased by 8% in 2014 (Eurostat, 2022a). The application of P in Ireland increased in 2013 by 14% compared to the previous year, with 22.5kg/ha being applied (Eurostat, 2022a). Between the years 2013 and 2017, the application of P had increased by 12%, with 25.2kg/ha being applied (Eurostat, 2022a).



*Figure 7.4: Fertiliser input of N and P in Ireland between 2010 and 2017 (Source: Eurostat, 2022a). Displayed in kg per hectare.* 

# 7.4 Agricultural Land Use

In Ireland, agriculture accounts for 67.6% of the national land cover (EPA, 2022a), whereas grassland accounted for 59.3% of total land use in Ireland in 2019 (CSO, 2021). According to Figure 7.5, agricultural land use in Ireland has remained relatively stable between 2013 and 2020, decreasing slightly by 4% between 2020 and 2021 (CSO, 2022d). This decrease in land use in agriculture in Ireland is also evident at a NUTS 2 level in the Eastern and Midland region, which decreased by 5% between 2020 and 2021, followed by the Northern and Western region by 4% and the Southern region by 3% (Figure 7.6; CSO, 2022d).





Figure 7.5 Land use for the agriculture sector in Ireland from 2013 and 2021 (Source: CSO, 2022d). Agricultural area utilised (UAA), displayed in '000 hectares.



Figure 7.6 Land use for the agriculture sector in the NUTS 2 regions of Ireland from 2013 and 2021 (Source: CSO, 2022d). Agricultural area utilised (UAA), displayed in '000 hectares.

### 7.5 Horticulture in Ireland

Horticulture in Ireland including the production of fruit, vegetables and plants, has a direct purchase value in Ireland of approximately 400m euros. There are two sectors associated with horticulture in Ireland, food and convenience produce. These sectors are associated with the production of mushrooms, potatoes, field vegetables, fruit, nursery stock, cut foliage, Christmas trees and bulbs.



The horticultural industry in Ireland is focused on supplying the domestic market, such as retail. The retail market for fresh produce was valued at 1.7b euros in 2020, which included 84m euros of fruit, 610m euros of vegetables and 242m euros of potato sales (Teagasc, 2021), however, this does not determine whether the produce was imported or produced locally. In addition, mushroom exports to the UK account for 75% of the mushrooms grown in Ireland and are valued at over 115m euros annually (Enterprise Ireland). Furthermore, in Ireland, an estimated 212 commercial field vegetable producers are growing around 4,600 ha of crops. The main soft fruit crop grown in Ireland is the fresh strawberry which accounts for over 90% of Irish berry production. This is worth an estimated  $\notin$ 47m per annum. Most strawberries are grown undercover, leading to an extended growing season (Teagasc, 2019). Ireland also has around 100 nursery stock producers, who produce plants for the domestic and export markets.

### 7.5.1 Horticulture Farms

Indoor horticulture has decreased in the Border, Midland and Western regions of Ireland between 2007 and 2016 with just 10 indoor horticulture farms recorded in 2016 (Figure 7.7A; 2022b). However, the number of indoor horticulture farms in the Southern and Eastern regions of Ireland is greater with 30 farms recorded in 2016. Although, in the Southern and Eastern regions this number has decreased by 40% between 2013 and 2016. Indoor crops in Ireland include strawberries with at least 8,000 tonnes of fresh strawberries produced each year (Teagasc, 2019). Specialist or citrus fruit farms are greater in the Southern and Eastern regions of Ireland, compared to the Border, Midland and Western regions (Figure 7.7D, 2022b). Although the farm number decreased by 40% in the Southern and Eastern regions of Ireland between 2007 and 2013 this decrease has stabilised and there have been 30 specialist fruit farms recorded in this region in both 2013 and 2016.

Outdoor horticulture in Ireland, in terms of farm numbers, has decreased by 94% between 2007 and 2016 and this decrease in farm numbers is evident in both the Border, Midland and Western regions and the Southern and Eastern regions (Figure 7.7B; 2022b). Raspberry production is an example of outdoor horticulture crops in Ireland, however, apples are a top-selling fruit in Ireland that is grown outdoors. Other types of horticulture, such as blueberries that can be grown either indoors or outdoors, are increasing in the Southern and Eastern regions of Ireland, with a 25% increase in farm numbers between 2013 and 2016 (Figure 7.7C; 2022b).





Figure 7.7: Number of (A) indoor, (B) outdoor, (C) other and (D) specialist and citrus fruit farms in Ireland (Source: Eurostat, 2022b).

### 7.5.2 Agricultural Area used for Horticulture

According to the CSO, in 2016, 71,100ha in Ireland were used for other crops such as beans & peas, oilseed rape, arable & maize silage, kale, turnips and potatoes, fruit and horticulture (CSO, 2016). The total apple production area in Ireland in 2017 was 713ha (Teagasc, 2019). This represents a 16% increase from the previous census (615ha in 2012). In addition, the dessert apple production area was up 75% from the previous census (from 122ha in 2012 to 214ha in 2017). This increase can be linked to new opportunities in Ireland for dessert apples in the juicing and cider markets.

The UAA for indoor horticulture in Ireland overall increased by 362% between 2007 and 2016 (Figure 7.8A; Eurostat, 2022b), particularly in the Southern and Eastern regions with up to 1,170 ha used for indoor horticulture in 2016. On the other hand, the area used for outdoor horticulture in Ireland dramatically decreased by 91% between 2007 and 2016 from 8,130 ha to 710 ha (Figure 7.8B; Eurostat, 2022b). However, there has been a 6% increase in UAA in outdoor horticulture in Ireland between 2013 and 2016.

The area used for other horticulture in Ireland has increased by 48% between the years 2013 and 2016 (Figure 7.8C; Eurostat, 2022b). Again, this increase is reflected in the Border, Midland and Western regions, and the Southern and Eastern regions in Ireland with a 5% and a 71% increase in UAA for other horticulture between 2013 and 2016, respectively. However, the area used for specialist and citrus fruit in Ireland has decreased by 77% between 2007 and 2016 (Figure 7.8D; Eurostat, 2022b) and this decrease is evident in the NUTS 2 regions also.





Figure 7.8: Utilised agricultural area for (A) indoor, (B) outdoor, (C) other and (D) specialist and citrus fruit farms in Ireland (Source: Eurostat, 2022b). Displayed in hectares.

### 7.5.3 Horticulture Output

Horticulture contributes substantially to the Irish economy annually. Strawberry production has an estimated worth of 47m euros in 2019 and raspberries have an estimated value of 4m euros per year (Teagasc, 2019). Indoor horticulture output increased considerably in Ireland between 2007 and 2016, from 2m to 48m euros which is a 2300% increase over nine years (Figure 7.9A; Eurostat, 2022b). In addition, the output in the Border, Midland and Western regions in Ireland increased by 1300% from 1m to 14m euros. However, the output in the Southern and Eastern regions decreased by 26% between 2013 and 2016 (Eurostat, 2022b).





Figure 7.9: Standard output for (A) indoor, (B) outdoor, (C) other and (D) specialist and citrus fruit farms in Ireland (Source: Eurostat, 2022b). Displayed in '000,000 Euros.

The standard output for outdoor horticulture has decreased considerably since 2007 (Figure 7.9B) which reflects the trends in the farm number (Figure 7.7B) and UAA (Figure 7.8B). The output for outdoor horticulture reduced by 97% between 2007 and 2016 from 91m to 3m euros, respectively. On the other hand, although other horticulture is decreasing in Ireland with it valued at 67m euros in 2016, it has increased by 31% in the Southern and Eastern regions between 2013 and 2016 (Figure 7.9C; Eurostat, 2022b). Again, the output for specialist and citrus fruit in Ireland has declined, by 75% between 2013 and 2016 (Figure 7.9D), which reflects the trend in farm numbers (Figure 7.7) and UAA (Figure 7.8).

### 7.6 Chapter Summary

Overall, the price of mineral fertilisers is increasing in Ireland, mainly due to sanctions imposed on Russia, because of the Russia-Ukraine war. The sale of fertiliser NPK continued to increase up until 2019, even though the Irish Government aims to reduce N fertiliser use on Irish farms from a high of 408,000t in 2018 to 325,000t by 2030 (Moran 2021) however, the data is unavailable for the year 2022 at the time of compiling this report. Although, it is predicted that the sale of fertilisers will decrease by the end of 2022 due to the lack of availability.

In general, the number of farms practising horticulture in Ireland is decreasing, except for those practising other horticulture, which was observed to increase between 2013 and 2016. In addition, other horticulture farms in the Southern and Eastern regions of Ireland increased, and specialist and citrus fruit farms in the same region remained the same between 2013 and 2016 respectively. The agricultural area used for indoor horticulture in Ireland and the Border,



Midland and Western regions are increasing between 2007 and 2016, in addition, the agricultural area for other horticulture is also increasing between 2013 and 2016 in Ireland and the Southern and Eastern regions. Furthermore, the standard output for indoor horticulture in Ireland has increased since 2013 and has remained the same between 2013 and 2016. In addition, the standard output for other horticulture in the Southern and Eastern regions increased between 2013 and 2016.

Considering the number of farms growing other types of horticulture crops such as arable & maize silage, kale, turnips and potatoes is increasing and the agricultural area used for indoor horticulture is increasing indicates that there is a demand in Ireland for fertilisers, although to a much lesser extent than in the agriculture sector. However, sanctions imposed by the EU on Russia due to the war with Ukraine, resulting in an energy crisis in Ireland will impact the availability of fertilisers in Ireland. As a result, there is an excellent opportunity for RDFs to enter the market in Ireland and substitute mineral fertilisers in the horticulture sector.

#### Luxembourg 8

#### **Fertiliser Price** 8.1

The price of fertiliser in Luxembourg fluctuated between 2008 and 2021 (Figures 8.1 and 8.2). There is a gradual increase in fertiliser prices evident between the years 2019 and 2021 which reflects the logistical issues with the supply chain during Covid-19 in 2019 - 2020, and the China export ban of 2021. This trend is particularly evident in the price of UAN, which increased by 12.5% from 232 euros/t to 261 euros/t between 2020 and 2021 (Figure 8.1; Lëtzebuerg Farming Portal, 2022). Likewise, the price of CAN increased by 20% from 215 euros/t to 258 euros/t during the same period.





Figure 8.1: Fertiliser prices of nitrogen based fertilisers ammonium sulphate nitrate (ASN), urea ammonium nitrate (UAN) and calcium ammonium nitrate (CAN) in Luxembourg from the years 2008 to 2021 (Source: Lëtzebuerg Farming Portal, 2022). Data is displayed as euros per tonne.



On the other hand, the price of DAP decreased by 15% from 492 euros/t to 419 euros/t between 2019 and 2020 (Figure 8.2; Lëtzebuerg Farming Portal, 2022). This was also evident in the price of CAN during the same period, where an 11% decrease from 241 euros/t to 215 euros/t in fertiliser price was observed (Lëtzebuerg Farming Portal, 2022). Due to the small size of Luxembourg as a country, these results are not indicative of fertiliser prices across NWE.



Figure 8.2: Fertiliser prices of potash (60%), diammonium phosphate (DAP) 18/46 and NPK 15/15/15 in Luxembourg from the years 2008 to 2021 (Source: Lëtzebuerg Farming Portal, 2022). Data is displayed as euros per tonne.

# 8.2 Fertiliser Sales

For fertiliser sales in Luxembourg statistics are tied to the statistics for Belgium, refer to Chapter 4, Section 4.2, Fertiliser Sales in the Belgo-Luxembourg Economic Union.

### 8.3 Fertiliser Use

Nitrogen fertiliser use in Luxembourg peaked in 2011 with 255.6kg/ha used (Figure 8.3A), however, it has remained relatively stable at between 246 - 256kg/ha (Eurostat, 2022a). Similarly, the use of P has remained relatively consistent at 20-21kg/ha from 2010-2014. (Figure 8.3B). However, the lack of data from 2014 – 2021 on the use of fertilisers in Luxembourg, makes it difficult to understand their current use in the horticulture sector which has a knock-on effect in determining the potential demand for RDFs in Luxembourg.



Figure 8.3: Fertiliser input (N and P) in Luxembourg between 2010 and 2014 in kg per hectare (Source: Eurostat, 2022a).

# 8.4 Agricultural Land Use

In Luxembourg, the main agricultural areas are located by the floodplain of the Moselle River. However, agriculture in Luxembourg has been in decline and currently and according to Lloyds Bank, the country's arable land is limited to just 61,860 hectares. Due to its moderate climate, various crops can thrive in Luxembourg, however, poor soil limits crop production in many areas. Luxembourg's main agricultural products are barley, oats, potatoes, wheat, fruits, and grapes for wine production. On average, 42% of the land is arable, with 1% used for permanent crops, such as vineyards (Nation Encyclopaedia, 2012). The amount of land used for agriculture in Luxembourg decreased by 1.5% between the years 2009 and 2015, however, this increased by 0.75% by 2018 (Figure 8.4; Eurostat, 2021b).



*Figure 8.4: Agricultural Land Use in Luxembourg from 2009 and 2018 (Source: Eurostat, 2021b). Displayed in hectares.* 



# 8.5 Horticulture in Luxembourg

One of the main horticulture crops produced in Luxembourg is grapes for wine production, with many vineyards situated along the Moselle River, which covers 1% of agricultural land (1,200 hectares). These vineyards can produce up to 15m litres of wine annually (Nation Encyclopaedia, 2012).

#### 8.5.1 Horticulture Farms

Overall, there were ten indoor and outdoor horticulture farms recorded in Luxembourg from 2007 to 2010 (indoor, with no recent data available since then) and 2016 (outdoor) see Figure 8.5A (Eurostat, 2022b). In 2010, the farms that were involved with other horticulture peaked with 20 farms recorded, this has since decreased by 50% to ten farms in 2016 (Figure 8.5B; Eurostat, 2022b). However, vineyards are the most commonly occurring type of farm in Luxembourg with 380 farms recorded in 2007 (Figure 8.5C; Eurostat, 2022b). The number of vineyards progressively decreased by 26% between 2007 and 2016 from 380 farms to 280 farms recorded. In addition, the number of specialist and citrus fruit farms has increased in Luxembourg by 100% from 10 farms in 2010 to 20 farms in 2016 but still only returning to the 2007 levels (Figure 8.5D; Eurostat, 2022b).



Figure 8.5: Number of (A) indoor/ outdoor, (B) other, (C) vineyard and (D) specialist and citrus fruit farms in Luxembourg from 2007 to 2016 (Source: Eurostat, 2022b).

### 8.5.2 Agricultural Area used for Horticulture

According to the Climate Change Post for Luxembourg (2022), in 2008, there were over 2,200 farms recorded covering just over 50% of Luxembourg's territory. Half of that territory was



identified as arable land, the other 50% was used for permanent pasture and meadows. The permanent pasture and meadows were mainly grazing land and permanent crops, in particular vineyards. However, considering Luxembourg's small size, this is representative of a very small area of land.

The area of land used for indoor horticulture in 2007 decreased from 20 ha to 10 ha in 2010. However, the agricultural area used for outdoor horticulture increased by 1300% between 2007 and 2016 (Figure 8.6A) from 10 - 140 ha albeit from a low level (Eurostat, 2022b). The agricultural area used for other horticulture increased by 190% from 2007 to 2010, however, this decreased by 69% from 290 ha in 2010 to 90 ha in 2016 (Figure 8.6B; Eurostat, 2022b).



Figure 8.6: Utilised agricultural area for (A) indoor/outdoor, (B) other, (C) vineyard and (D) specialist and citrus fruit farms in Luxembourg from 2007 to 2016 (Source: Eurostat, 2022b). Displayed in hectares.

The agricultural area used for the vineyards in Luxembourg decreased gradually by 24% from 1650ha in 2007 to 1250ha in 2016 (Figure 8.6C; Eurostat, 2022b). On the other hand, the area used for specialist and citrus fruits decreased in 2010 to 70ha, however, this gradually increased by 86% to 130ha in 2013 (Figure 8.6C; Eurostat, 2022b). Overall, however, the area of land available for horticulture use is very small compared to its European counterparts.

### 8.5.3 Horticulture Output

Luxembourg is a successful exporter of wine, exporting to markets in Belgium, Germany, France, Finland and Canada. By 2007 the indoor horticulture output in Luxembourg was valued at 2.6m euros, however, this had decreased by 88% by 2010 (Figure 8.7A; Eurostat, 2022b). On the other hand, the outdoor horticulture output increased by 460% between 2007 and 2016. Other horticulture in Luxemburg peaked in 2010 at over 6m euros, however, this



decreased by 65% from 2010 to 2013 (Figure 8.7B; Eurostat, 2022b). Although, the standard output started to increase again in 2016 by 13% from 2013.



Figure 8.7: Standard output for (A) indoor/outdoor, (B) other, (C) vineyard and (D) specialist and citrus fruit farms in Luxembourg, from 2007 to 2016 (Source: Eurostat, 2022b). Displayed in millions of euros.

Standard output for vineyards in Luxembourg decreased by 13% between 2007 and 2016 (Figure 8.7C; Eurostat, 2022b). On the other hand, the output for specialist and citrus fruit has increased since 2010. From 2010 to 2016, it increased by 107% with a standard output valued at just under a million in 2016 (Figure 8.7D; Eurostat, 2022b).

# 8.6 Chapter Summary

The use of N and P fertiliser is increasing in Luxembourg however recent data from 2014 to 2022 on fertiliser use is lacking, making it difficult to understand their current use in the horticulture sector. The price of N based fertilisers increased between 2020 and 2021, this mirrors the price increases observed across NWE. Agricultural land use is increasing albeit at a very low level and slow rate, considering the country's arable land is limited to just 61,860 hectares, there is very limited space for expanding the agriculture sector in Luxembourg.

Outdoor horticulture UAA is considerably higher than indoor, even though the number of farms is the same which reflects on the standard output (euros). The number of specialist and citrus fruit farms is increasing in Luxembourg in addition to the area used for these farms and the output. Taking into account the size of the country, this is reflected in the size of the horticulture sector, therefore the potential market for RDFs in Luxembourg is also very small.



# **9** The Netherlands

# 9.1 Fertiliser Price

The Netherlands spent over 900m euros on fertiliser imports in 2021 (Fertiliser Trading, 2022) and the price of fertiliser continues to increase in response to the Ukraine-Russian war and sanctions imposed on Russia from the West. The price of urea increased steadily by 55% from January to September 2021 (Figure 9.1; Wageningen University, 2022). However, between September and October 2021, the price increased by 94%. The price of urea continued to increase by a further 7.5% between November 2021 and February 2022.





Similarly, the price of potassium chloride steadily increased from January to September 2021, increasing by 21% over that period (Figure 9.1; Wageningen University, 2022). Between September and October 2021 however, the price of potassium chloride increased from 354 euros/t to 530 euros/t, which is a 50% increase. On the other hand, the price of TSP increased consistently from January 2021 to February 2022 (Wageningen University, 2022).

Overall, the price of fertiliser in the Netherlands increased considerably between February 2021 February and 2022, except for magnesium oxide with a 3% increase during that year (Figure 9.2; Wageningen University, 2022). However all other fertiliser products increased substantially, in particular, urea ammonium nitrate increased from 219 to 645 euros/t or by 194%, calcium ammonium nitrate increased by 170%, from 235 to 636 euros/t and calcium ammonium nitrate + S increased by 167% from 245 to 652 euros/t (Wageningen University, 2022). Although, these prices do not reflect the fertiliser price increases as a result of the sanctions imposed on Russia by the EU, which occurred after February 2022.





### Price of Fertilisers in the Netherlands

*Figure 9.2: Price of fertilisers in the Netherlands in February 2021 and 2022 (Source: Wageningen University, 2022). Displayed in euros/tonne.* 

### 9.2 Fertiliser Sales

The sales of N and P in the Netherlands have been decreasing. The Netherlands are a significant importer of N in the European Union, with the volume of imports reaching 324m cubic meters, imported in 2021 (IndexBox, 2022). It is clear in Figure 9.3A, that the sales of N in the Netherlands are decreasing steadily, with N sales at 239,000t in 2008, and decreasing to 202,000t in 2019 (Eurostat, 2021c). Furthermore, the sales of P decreased by 40% between 2012 and 2013 (Figure 9.3B; Eurostat, 2021c), this is in line with the Nitrate Directive, where it was proposed that a reduction of P application standards to guideline levels for 2013 and 2015 would decrease P surplus on agricultural land. However, the sales of K have fluctuated over the years in the Netherlands (Figure 9.3C; Eurostat, 2021c), with sales increasing by 33% between 2008 and 2011. Similar to P sales, K sales decreased between 2012 and 2013 by 19% to 26,000t, increasing again to 32,000t by 2019.





Figure 9.3: Fertiliser sales of N, P and K in the Netherlands between 2008 and 2019 (Source: Eurostat, 2021c). Displayed in '000 tonnes.

### 9.3 Fertiliser Use

Although N sales decreased between 2008 and 2019, its use in the Netherlands continued to increase (Figure 9.4A; Eurostat, 2022a). From the year 2012 to 2017, N use increased by 14%, however, between 2017 and 2019 N sales proceeded to decrease again by 8% from 402kg/ha to 369kg/ha. In recent years, from 2016 to 2019 the sales of P have decreased by 11% from 36kg/ha to 32kg/ha (Figure 9.4B; Eurostat, 2022a).



Figure 9.4: Fertiliser input of N and P in the Netherlands between 2010 and 2017 (Source: Eurostat, 2022a. Displayed in kg per hectare.).



# 9.4 Agriculture Land Use

According to the Climate Change Post (2022), next to the US, the Netherlands is the second largest exporter of agricultural products in the world. Exports of Dutch agricultural products in 2018 were valued at 90.3b euros. The top four NUTS 2 regions associated with the highest land use in agriculture are highlighted in Figure 9.5. Land use in Friesland has stayed relatively even between 2009 and 2018, land use in Overijssel increased from 220,000ha in 2015 to 240,000ha in 2018 (Eurostat, 2021b). On the other hand, the land used for agriculture in Gelderland and Noord-Brabant has decreased slightly by 7% and 11% respectively between 2015 and 2018 (Eurostat, 2021b).





Figure 9.5 Land use for the agriculture sector in the NUTS 2 regions in the Netherlands from 2009 to 2018 (Source: Eurostat, 2021b). The top four regions with the largest land used in the agriculture sector in the Netherlands are displayed as '000 hectares.

# 9.5 Horticulture in the Netherlands

The Netherlands is the second largest exporter of agricultural and food products in the world. Along with Spain and the US, the Netherlands is one of the main producers of fruit and vegetables, and supplies about a quarter of the vegetables for export to Europe. The Netherlands is globally the main exporter of live trees, plants, bulbs, roots and cut flowers, with a 44% share of the worldwide trade in flowers and floricultural products. The Dutch are experts on indoor horticulture with up to 9,300 ha of high-tech greenhouses, the equivalent of 80% of cultivated land under greenhouse glass (Nature Rising, 2022).

### 9.5.1 Horticulture Farms

The number of horticulture farms in the Netherlands decreased between 2007 and 2016 (Figure 9.6A; Eurostat, 2022b), however, indoor horticulture is the most prevalent with 2,890 farms in 2016, followed by other types of horticulture with 2,390 farms recorded in 2016. With regards to indoor horticulture, Zuid-Holland has the highest number of farms however the number of farms there decreased by 47% between 2007 and 2016 (Figure 9.6B; Eurostat, 2022b). Noord-Holland has the highest number of outdoor horticulture farms with 1,040 farms



in 2007, reduced to 780 in 2016 (Figure 9.6C; Eurostat, 2022b). Noord-Brabant has the highest number of other horticulture farms, with 890 farms recorded in 2016 (Figure 9.6D; Eurostat, 2022b). Gelderland has the highest number of vineyards in the Netherlands (Figure 9.6E; Eurostat, 2022b), whereas Gelderland also has the highest number of specialist/citrus fruit farms too, with 470 farms recorded in 2016 (Figure 9.6F; Eurostat, 2022b).





Figure 9.6: Number of (A) overall number of farms in the horticulture sector (B) indoor, (C) outdoor, (D) other, (E) vineyard and (F) specialist and citrus fruit farms in the Netherlands. Figures B-F displays the regions with the highest number of farms in the Netherlands (Source: Eurostat, 2022b); (G) The largest number of outdoor horticulture farms produce horticulture products in the Netherlands (Source: StatLine).



Furthermore, the number of farms that produce flower bulbs and tubers, tree nurseries and perennials, apples and pears has decreased between 2010 and 2015, however, the number of farms has remained relatively stable since 2020 (Figure 9.6G; StatLine).

### 9.5.2 Agricultural Area used for Horticulture

Outdoor horticulture utilises the most agricultural land in the Netherlands, with over 58,000ha used in 2016, which was a 7% increase on outdoor horticulture UAA in 2013 (Figure 9.7A; Eurostat, 2022b). Other horticulture farms use the next highest area of land with 26,980ha used in 2016 (Figure 9.7D; Eurostat, 2022b). Zuid-Holland has the highest area of land used for indoor horticulture, with 5,180ha used in 2016 (Figure 9.7B), whereas Noord-Holland has the largest area of land used for outdoor horticulture, with 22,780ha used in 2016 (Figure 9.7C; Eurostat, 2022b). Noord-Brabant has the highest land used for other types of horticulture with 11,620ha used in 2016 (Figure 9.7D), on the other hand, Gelderland and Zeeland have the highest area of land used for specialist and citrus fruit, with 6,070ha and 6,180ha used in 2016 respectively (Eurostat, 2022b).



Figure 9.7: Utilised agricultural area for (A) the overall horticulture sector (B) indoor, (C) outdoor, (D) other, (E) vineyard and (F) specialist and citrus fruit farms in the Netherlands (Source: Eurostat, 2022b). Graphs B-F display the regions with the largest land area used for horticulture in the Netherlands, displayed in hectares.



The area used to grow flower bulbs and tubers in the Netherlands has increased by 20%, tree nurseries and perennials have increased by 2% and horticulture vegetables have increased by 8% from 2010 to 2022 (Figure 9.8; StatLine, 2022). In addition, the area used to grow cut flowers has increased consistently between 2019 and 2022, with 2,970 ha used in 2022.



■2010 ■2015 ■2020 ■2021 **■**2022

*Figure 9.8: Outdoor farm area used to grow various horticulture products in the Netherlands (Source: StatLine, 2022). Displayed in hectares.* 

### 9.5.3 Horticulture Output

In 2014 the Netherlands was the world's second-largest exporter (in value) of fresh vegetables (Nature Rising, 2022). Overall, indoor horticulture in the Netherlands is the most valuable to the economy, which was worth 4.69b euros in 2016 (Figure 9.9A; Eurostat, 2022b). With regards to indoor horticulture, Zuid-Holland has the highest standard output, with 2.555b euros in 2016 (Figure 9.9B), whereas Noord-Holland had the highest standard output in outdoor horticulture with 527m euros (Figure 9.9C; Eurostat, 2022b). The standard output for other horticulture was the highest in Noord-Brabant which was worth 493m euros in 2016 (Figure 9.9D; Eurostat, 2022b). Both Gelderland and Zeeland had high standard outputs for specialist/citrus fruit which were worth 122m euros and 109m euros in 2016 respectively.





Figure 9.9: Standard output for (A) the overall horticulture sector (B) indoor, (C) outdoor, (D) other, (E) vineyard and (F) specialist and citrus fruit farms in the Netherlands (Source: Eurostat, 2022b). Graphs B-F display the regions with the largest output for horticulture in the Netherlands displayed in '000,000 euros.

# 9.6 Chapter Summary

With rising electricity and gas prices the Norwegian chemical company, Yara, which produces, distributes, and sells nitrogen-based mineral fertilisers and related industrial products has had to close two of its three production plants due to high gas prices, the third factory is located in Sluiskil in the Netherlands. As a result, the total European ammonia capacity utilisation has been reduced to approximately 35%. This is the equivalent to the production of just 3.1mt ammonia and 4.0mt of finished products (1.8mt urea, 1.9mt nitrates and 0.3mt NPK) across its production system in Europe (Yara, 2022).

In 2021, the Netherlands spent over 900m euros on fertiliser imports (Fertiliser Trading, 2022), with the price of fertiliser continuing to increase. As a result of increasing fertiliser prices, the sales of N and P in the Netherlands have been decreasing. The Netherlands are a significant



importer of N in the European Union, with the volume of imports reaching 324m cubic meters, which was equivalent to 33% of the total materials imported in 2021 (IndexBox, 2022).

The Netherlands is one of the main producers of fruit and vegetables and is the second largest exporter of agricultural and food products in the world. It supplies approximately a quarter of the vegetables for export to Europe and is globally the main exporter of live trees, plants, bulbs, roots and cut flowers, with a 44% share of the worldwide trade in flowers and floricultural products. The Dutch are experts on indoor horticulture with up to 9,300ha of high-tech greenhouses, the equivalent of 80% of cultivated land under greenhouse glass (Nature Rising, 2022). Most indoor horticulture farms, particularly in Zuid-Holland were also associated with the highest standard output (euros).

Outdoor horticultural land in the Netherlands is used to grow flower bulbs and tubers, perennials, and fruit trees such as apples and pears. Furthermore, the area used to grow flower bulbs and tubers in the Netherlands had increased by 20% and horticulture vegetables have increased by 8% from 2010 to 2022.

Considering the sophisticated high-tech greenhouses that are quoted by Nature Rising (2022) that "At optimal growing conditions, each acre in the greenhouse yields as much lettuce as 10 acres outdoors" and the vast area of land utilised for horticulture, there is an excellent potential market for RDFs in the Netherlands.

# **10 The United Kingdom**

# **10.1 Fertiliser Price**

The price of agricultural fertiliser has risen significantly over the past year. According to the Agriculture and Horticulture Development Board (AHDB) in May 2022, the price of UK-produced ammonia nitrate fertiliser in the UK increased by 152% since May 2021 and import prices increased by 171%. The price of potassium chloride fertiliser (potash) had increased by 165% and phosphate fertilisers had increased by between 120% and 128% depending on the type (AHDB, 2022). This price increase is evident in Figure 10.1 with a 158% increase in the price of ammonium nitrate (produced), a 155% increase in ammonium nitrate (imported) and a 121% increase in muriate of potash between July 2021 and July 2022 (AHDB, 2022). In addition, there was an 11% increase in the price of ammonium nitrate (produced) and a 7% increase in ammonium nitrate (imported) in the month between June and July 2022 (AHDB, 2022).





■ 2021 July ■ 2022 June ■ 2022 July

Figure 10.1: Price of different fertilisers in the United Kingdom in July 2021, and June and July 2022 (Source: AHDB, 2022). Displayed in euros per tonne.

### **10.2 Fertiliser Sales**

The sales on NPK, like many European countries are decreasing, however, they have not dropped to as low as the 2008 sales. After 2008 N sales peaked in 2010 at 1,021,000t, however, sales dropped again in 2012 by 7% (Figure 10.2A; Eurostat, 2021c). Since 2012, N sales increased in the UK and have stabilised, however between 2018 and 2019, sales dropped by 7%. P sales remained relatively consistent between 2009 and 2016, however between 2015 and 2019 P sales decreased by 8% from 85,000t to 78, 000t (Figure 10.2B; Eurostat, 2021c). The sale of K decreased between 2010 and 2011 by 9%, however, this increased by 8% by 2012 (Figure 10.2C). Between 2016 and 2019 the sale of K decreased by 8% (Eurostat, 2021c).

### **10.3 Fertiliser Use**

Between 2010 and 2012 the use of N fertiliser decreased by 3% from 197kg/ha to 190kg/ha, however, N use increased by 2014 (Figure 10.3A; Eurostat, 2022a). In 2017 N sales had reached 195kg/ha. The use of P, however, has remained unchanged between 2010 and 2017, with 24kg/ha used consistently (Figure 10.3B; Eurostat, 2022a).





*Figure 10.2: Fertiliser sales of N, P and K in the United Kingdom between 2008 and 2019 (Source: Eurostat, 2021c). Displayed as '000 tonnes.* 



Figure 10.3: Fertiliser input of N and P in the United Kingdom between 2010 and 2017 (Source: Eurostat, 2022a). Displayed in kg per hectare.

# **10.4 Agriculture Land Use**

In the UK, agriculture accounts for 72% of land use and employs nearly half a million people. Most of the arable cropland is located in the lowlands of southeast Great Britain, which have relatively warm temperatures and lower rainfall (Climate Change Post, 2022). Agricultural land use had decreased since 2009, however, has remained relatively stable between 2012 and 2018. In 2018 132,904 ha was used for agriculture (Figure 10.4; Eurostat, 2021b).





*Figure 10.4: Agricultural Land Use in the United Kingdom from 2009 and 2018 (Source: Eurostat, 2021b). Displayed in '000 hectares.* 

# **10.5 Horticulture in the United Kingdom**

The horticulture business, including food production, in the UK, is worth over 5b pounds each year (UK Parliament, 2022). British farmers produce 3.5m tonnes of fruit and vegetables every year and grow 14,000 ha of plants and flowers. In total, 56% of the vegetables and 16% of the fruit that is consumed in the UK are produced in the UK. In addition, one of the fastest growing sectors of UK horticulture is vines for wine production (Countryside, 2020). Grape growing and winemaking in the UK have changed considerably throughout the last 50 years. England and Wales now have approximately 6200 acres of vineyards (Countryside, 2020).

### **10.5.1 Horticulture Farms**

Overall, most horticulture farms in the UK are in the specialist/citrus fruit sector (Figure 10.5A) with 1,660 farms in 2013 decreasing to 1,640 farms in 2016. Indoor horticulture farms were the highest in 2007 with 2,510 farms, however, this has reduced considerably by 2016 (Figure 10.5A). Lancashire currently has the most indoor horticulture farms with 80 farms in 2016, this, however, was a decrease of 53% from the 2007 farm number (Eurostat, 2022b). The highest number of outdoor horticulture farms in the UK are in Lincolnshire, Cornwall and the Isles of Sicily with 70 farms respectively in 2016 (Figure 10.5C; Eurostat, 2022b). Other horticulture farms are highest in Northern Ireland, the number of farms has increased in this area between 2010 and 2016, with 70 other horticulture farms present in 2016 (Figure 10.5D; Eurostat, 2022b). The number of vineyards has increased in Surry, East and West Sussex between 2013 and 2016 by 100%, also, the number of vineyards in Hampshire and the Isle of Weight has increased since 2010 (Figure 10.5E; Eurostat, 2022b). In 2016, the number of specialist/ citrus fruit farms in the UK was highest in Herefordshire, Worcestershire and Warwickshire, and in Kent with 300 and 280 specialist fruit farms recorded, respectively (Figure 10.5F; Eurostat, 2022b).





Figure 10.5: Number of (A) overall farms in the horticulture sector (B) indoor, (C) outdoor, (D) other, (E) vineyard and (F) specialist and citrus fruit farms in the United Kingdom (Source: Eurostat, 2022b). Graphs B-F displays the regions with the highest number of farms in the UK.

### 10.5.2 Agricultural Area used for Horticulture

There are 35,000 hectares of peas grown in the UK each year alone, equivalent to about 70,000 football pitches (Countryside, 2020). However, the most amount of land in the UK is used for specialist or citrus fruit (Figure 10.6A), which has increased by 45% between 2007 and 2016 (Eurostat, 2022b). The most land used for indoor horticulture in the UK is in Eastern Scotland, which has increased by 944% between 2010 and 2016 (Figure 10.6B; Eurostat, 2022b).





Figure 10.6: Utilised agricultural area for (A) the overall horticulture sector (B) indoor, (C) outdoor, (D) other, (E) vineyard and (F) specialist and citrus fruit farms in the United Kingdom (Source: Eurostat, 2022b). Graphs B-F displays the regions with the largest land area used for horticulture in the UK, displayed in hectares.

The area used for outdoor horticulture in Cornwall and the Isle of Sicily decreased by 39% between 2013 and 2016; however, it still has the largest agricultural area used for outdoor horticulture (Figure 10.6C; Eurostat, 2022b). In 2013, East Anglia had the highest area used for other horticulture with 2,990 ha, however, Eastern Scotland in 2016 had the highest area with 1,210 ha (Figure 10.6D; Eurostat, 2022b). The most agricultural area used for vineyards is in Surrey, East and West Sussex with 1030 ha, which is a 544% increase between 2013 and 2016 (Figure 10.6E; Eurostat, 2022b). Kent has the largest agricultural land used for specialist or citrus fruit with an 11% increase between 2013 and 2016 (Figure 10.6F), however, the levels are still lower than the 2007 and 2010 figures (Eurostat, 2022b).

### **10.5.3 Horticulture Output**

In the UK, the farm gate value of fruit, vegetables, plants and flowers that are grown and produced is approximately 4.16b euros (Countryside, 2020). In 2007, indoor horticulture had



the highest output in the UK with 816m euros produced, however, this changed and in 2013 and 2016, other types of horticulture contributed the most to the economy with 637m euros produced in 2016 (Figure 10.7A; Eurostat, 2022b).

The highest standard output from indoor horticulture was in Eastern Scotland with 147m euros in 2016 (Figure 10.7B), whereas the output for outdoor horticulture was highest in Cornwall and the Isles of Sicily (Figure 10.7C; Eurostat, 2022b). Other horticulture standard output was the highest from East Anglia, with 85m euros produced in 2016 (Figure 10.7D; Eurostat, 2022b). Kent has the highest standard output for vineyards and specialist/citrus fruit with 25m euros and 154m euros produced in 2016 (Figure 10.7E and F; Eurostat, 2022b).



Figure 10.7: Standard output for (A) the overall horticulture sector (B) indoor, (C) outdoor, (D) other, (E) vineyard and (F) specialist and citrus fruit farms in the United Kingdom (Source: Eurostat, 2022b). Graphs B-F displays the regions with the largest output for horticulture in the UK displayed in '000,000 euros.



### **10.6 Chapter Summary**

The UK consumed approximately 1.4m metric tonnes of chemical fertilisers in 2020, this value has remained relatively stable in the last ten years. In addition, N is the most used fertiliser nutrient in the UK, with almost one million metric tonnes consumed in 2020 (Statista, 2022). This confirms the findings in this report where the use of N had increased slightly between 2016 and 2017, however, the use of P has remained the same for seven years.

In recent years, there has been a 158% increase in the price of ammonium nitrate (produced), a 155% increase in ammonium nitrate (imported) and a 121% increase in muriate of potash between July 2021 and July 2022. BBC News (2022) interviewed a British Farmer that reported fertiliser costs for their farm were expected to increase from 17,133 euros to 41,119 euros - a 140% increase in 2022. These price increases have affected the sales of NPK where N sales have decreased by 7% between 2018 and 2019.

Horticulture in the UK accounts for about 3% of the UK's agricultural area, with more than 300 different types of vegetable, salad and fruit crops, ornamental plants and flowers produced, with a combined value of 4.16b euros (Countryside, 2020). Furthermore, the Chartered Institute of Horticulture has said that business, production, and food in the UK horticulture industry are worth over 5.71b euros each year (UK Parliament, 2022). Most horticulture farms in the UK grow specialised fruit or citrus fruit, where most of these types of farms are found in Herefordshire, Worcestershire and Warwickshire, and in Kent in 2016. However, the highest standard output in euros was incurred with other types of horticulture including seed, bulb and tuber production, particularly in East Anglia in 2016.

With considerable increases in fertiliser prices observed for UK Farmers and indeed across NWE, due to sanctions imposed by the EU on Russia, there is currently a gap in the market for readily available, locally produced and sustainable fertilisers. Considering the UK's thriving horticulture industry, there is an excellent opportunity for RDFs to fill the market gap.

# **11Discussion and Conclusion**

With depleting global P reserves, the unsustainable production of N and security of supply issues, it is clear that the fertiliser industry and its current production must change. In addition, with increasing fertiliser prices, most recently with Covid-19 and the Russian-Ukraine war, the demand for more cost-efficient locally sourced fertilisers is increasing. The European fertiliser industry is finding itself in an increasingly difficult position in terms of sourcing raw materials, which is impacting fertiliser production. Furthermore, many fertiliser plants are closing down due to soaring natural gas prices, CF Industries had closed its two plants in the UK in Ince and Billingham, due to the current pricing situation, with no estimated timeline given for when production will resume (Cockerill, 2021). Also, Yara International, the world's second-largest producer of ammonia has reduced its ammonia fertiliser production in Europe to 40% and has closed two of its three main factories in Europe, in addition to reducing ammonia production


at a number of its other European sites, due to the record high gas prices and the impact on margins (Cockerill, 2021). According to Fertilisers Europe, three-quarters of fertiliser production has come to a halt, and many farmer organisations across Europe have been discussing the need for national fertiliser reserves (Boeren Business, 2022a). Besides, the European Commission recently proposed to temporarily remove the import tariffs for certain fertiliser raw materials to bring down the production costs of fertiliser (Boeren Business, 2022b).

In the agricultural industry, fertiliser sales have been decreasing, with a growing interest in using more sustainably sourced fertilisers. In a study carried out by Egan *et al.* (2022) who explored the desired properties of RDFs among farmers, they found that farmers were willing to use these fertiliser alternatives, provided they met specific criteria including, compatibility with existing farm machinery, good nutrient value and availability at a good price. Currently, there is a gap in the market for the use of RDFs, not only in the agricultural sector, but the horticulture sector is a market with great potential for expanding the use of RDFs and encouraging them to be used and accepted outside of the agricultural market.

A summary of the demand for the availability and use of mineral fertiliser alternatives such as RDFs across NWE is highlighted in the following:

- In recent years, the price of fertilisers in NWE is increasing considerably, which has now been exasperated by the Ukraine-Russia war, among others. Potassium sulphate was the most expensive fertiliser to be purchased in Belgium in 2020. The price of potassium chloride gradually increased by 226% in France throughout 2021 and into 2022. In France, the price of urea increased by 96% by December 2021, whereas in Germany, it increased by 70% in 2021. In the Netherlands, the price of urea increased by 55% from January to September 2021 and between September and October 2021 the price increased by 94%, and in Ireland, the price of urea increased by 32% between 2020 and 2021. Overall, fertiliser prices in Ireland have increased by 178% in the first four months of 2022. The price of UK-produced ammonia nitrate fertiliser in the UK increased by 152% since May 2021 and imported prices had increased by 171%. It may be worth noting that price increases in 2021 and up to February 2022 were before the Ukraine-Russia war and the imposition of sanctions.
- The sales of fertiliser N and P varied per country, depending on their availability and use. The sales data is representative of fertiliser sales up to 2019, therefore the more recent sales data since the Ukraine-Russia war have not yet been published. The sales of NPK are increasing in the Belgo-Luxembourg Economic Union and Ireland, however, they are decreasing in the UK. In France and the Netherlands, the sales of N and P are decreasing and K sales are increasing. The sale of N and P in Germany is also decreasing, however, K sales have plateaued.
- Furthermore, fertiliser sales in France, in general, have been declining and the sales of mineral and organo-mineral fertilisers decreased by 4% in 2019. In addition, the sales of basic mineral fertilisers in France were down to 2.3m tonnes or a 6% decrease during the same period.
- In 2020, 157m hectares of land were used for agricultural production, that is, 38% of the total land area of the EU (Eurostat, 2022c). Furthermore, 11.2m tonnes of mineral



fertilisers (N&P) were used in agricultural production in the EU in 2020 (Eurostat, 2022d).

- In terms of volume, N is the most used nutrient in the EU, representing more than twothirds of the total use of NPK. Between 2010 and 2019, the Netherlands and Belgium were the most dominant users of N and P in NWE. Specifically, on average in the Netherlands, 375kg/ha of N and 35kg/ha of P and in Belgium, 312kg/ha of N and 32kg/ha of P were utilised over that period.
- Fertiliser use across NWE varied per country however, there was no data publically available for the use of K for any of the NWE countries of interest in this report. The use of N is decreasing and P is increasing in Belgium. Whereas the use of N and P is decreasing in France, Germany and Netherlands. In addition, the use of N and P is increasing in Ireland, while the use of N increased and P use plateaued in Luxembourg and the UK. However, there was a lack of recently available data, particularly for fertiliser use in Belgium and Luxembourg which was only available up to 2014.

Although a potential market has been identified in the horticulture sector for RDF use, there are some challenges associated with their application to crops for food. Such concerns include supplying horticulture crops with their full nutrient requirements by using only organic fertiliser, food safety concerns and EU regulations. Therefore it is important to advise potential users of the robust nature of these RDFs and the rigorous testing they go through. Further challenges with regards to assessing the horticulture market demand for these products arose, with recent official statistical data available lacking on the current price increases, number of horticulture farms, area of land used for agriculture and how much the horticulture sector is worth to the economy of each NWE country, with Eurostat reporting this information up until 2016. For a large part, the knowledge of this information for NWE is unknown after 2016.

A summary of the potential market demand for the use of RDFs in the horticulture sector across NWE is highlighted in the following:

- Up to 22% of all agricultural production can be classified as horticulture in Belgium, with 49% of the sector associated with vegetable production, 20% fruit and 31% ornamentals. Belgium is the largest producer of evergreen azaleas in the world, with up to 55m azaleas grown per year and a net worth of 36m euros in exports.
- France is one of the EU's leading agricultural nation, accounting for more than onefifth of the total value of output, and is responsible for more than one-third of the EU's production of wine. In 2022, wine production was expected to rise by 13-21% to between 42.6 m and 45.6m hectolitres.
- In Germany, 1,051,000t of apples were expected to be grown in 2022, with ornamental horticulture producing on average 1.5b bedding, balcony, herbaceous and perennial plants a year, in addition to 270m houseplants. Furthermore, up to 24,000 ha of land is used to grow deciduous, wild, coniferous, fruit and forest groves. German wine production from a total of 103,400 ha of vineyards covers approximately 35% of the wine consumed in Germany, with an estimated yield of 8.88m hectolitres of wine must produced in 2022.
- The main soft fruit crop grown in Ireland is the fresh strawberry which accounts for over 90% of Irish berry production and is worth approximately 47m euros annually. The total apple production area in Ireland in 2017 was 713 ha with retail sales valued at 131m



euros. Mushroom exports to the UK account for 75% of the mushrooms grown in Ireland and are valued at over 115m euros annually.

- The Netherlands is the second largest exporter of agricultural and food products in the world. It is one of the main producers of fruit and vegetables, and supplies about a quarter of the vegetables for export to Europe. The Netherlands is globally the main exporter of live trees, plants, bulbs, roots and cut flowers, with a 44% share of the worldwide trade in flowers and floricultural products. The Dutch are experts on indoor horticulture with up to 9,300 ha of high-tech greenhouses, the equivalent of 80% of cultivated land under greenhouse glass.
- Horticulture in the UK accounts for about 3% of the UK's agricultural area, with more than 300 different types of vegetable, salad and fruit crops, ornamental plants and flowers produced, with a combined value of 4.16b euros. British farmers produce 3.5m tonnes of fruit and vegetables every year and grow 14,000 ha of plants and flowers. In total, 56% of the vegetables and 16% of the fruit that is consumed in the UK are also produced in the UK. In addition, one of the fastest growing sectors of UK horticulture is vines for wine production.

In conclusion, the demand for mineral fertiliser alternatives is growing across NWE, even more so in the past three years due to Covid-19 and more recently the Ukraine-Russia war. Furthermore, the horticulture industry, although smaller than agriculture, has great potential for the use of RDFs and it is foreseen that this demand will increase in the near future. However, it has proven difficult to get an up-to-date (the past five years) image of the horticulture sector in NWE as a whole, with various knowledge gaps evident in areas such as the number of horticulture farms, the land area of farms used for horticulture and how much the horticulture sector is worth to the economy. Due to this lack of current information, it has proven difficult to predict what will happen in the horticulture sector in the future with regard to the use of fertilisers. This lack of knowledge impacts our ability to forecast future trends and inputs. Furthermore, obtaining current relevant information on the horticulture sector across NWE can contribute to our knowledge of potential food security issues and the security of fertiliser supply. The acceptance and use of RDFs in the horticulture sector would reduce the reliance on mineral fertilisers, and therefore, feed into closing the nutrient cycle loop and actively contribute to the circular economy.



## References

- Access to Land, a European network of grassroots organisations securing land for agroecological farming in Belgium, Access to Land, viewed on 17/11/22, <u>https://www.accesstoland.eu/Background-161</u>.
- Agriculture and Horticulture Development Board (AHDB), 2022. Great Britian fertiliser prices, Agriculture and Horticulture Development Board, viewed 06/12/22, <u>https://ahdb.org.uk/GB-fertiliser-prices.</u>
- Agriculture and Horticulture Development Board (AHDB), 2013. Grown in Britain. Your Guide To British Fresh Produce. Agriculture and Horticulture Development Board, viewed on 07/12/22,

https://projectblue.blob.core.windows.net/media/Default/Imported%20Publication%20 Docs/AHDB%20Horticulture%20/Grown%20in%20Britain%20Low%20res.pdf.

- Agriland, 2022, 'International prices reach highest ever levels.' Fertilisers'. Agriland Team, viewed on 06/12/22 <u>https://www.agriland.co.uk/farming-news/fertiliser-international-prices-reach-highest-ever-levels/</u>
- BBC News, 2022. Farmers hit by fertiliser price rise of 140% by Andrew Sinclair and Nic Rigby, BBC Politics East, viewed on 06/12/22, <u>https://www.bbc.com/news/uk-england-essex-61612876</u>.
- Bergstrand, K. J. (2022), 'Organic fertilizers in greenhouse production systems a review', Scientia Horticulturae, 295. <u>https://doi.org/10.1016/j.scienta.2021.110855</u>

Boeren Business, 2022a. News Fertilizer: EU fertilizer production continues to decline. Boeren Business, information provider for progressive farmers and agribusiness, viewed 07/12/22, https://www.boerenbusiness.nl/akkerbouw/artikel/10900562/kunstmestproductie-eu-

https://www.boerenbusiness.nl/akkerbouw/artikel/10900562/kunstmestproductie zakt-steeds-verder-weg

- Boeren Business, 2022b. EU wants to abolish levy on fertilizer raw materials. Boeren Business, information provider for progressive farmers and agribusiness, viewed 07/12/22, <u>https://www.boerenbusiness.nl/akkerbouw/artikel/10899714/eu-wil-heffing-kunstmest-grondstoffen-schrappen</u>
- Britannica, 2022, France, Agriculture, forestry, and fishing. Encyclopædia Britannica viewed 07/12/22, <u>https://www.britannica.com/place/France/Agriculture-forestry-and-fishing</u>
- Brock, J., Lange, M., Tratalos, J.A., Meunier, N., Guelbenzu-Gonzalo, M., More,S.J., Thulke, H. & Graham, D., 2022. The Irish cattle population structured by enterprise type: overview, trade & trends. Ir Vet J 75, 6. <u>https://doi.org/10.1186/s13620-022-00212-x</u>
- Chamber of Agriculture, 2022. Archive of the weekly market reports from the Rhineland-Palatinate Chamber of Agriculture, viewed 07/12/22 <u>https://www.lwk-rlp.de/de/marktstatistik/marktbericht/archiv/</u>
- Climate Change Post, 2022. Agriculture and Horticulture in Europe. Center for Climate Adaption, viewed on 07/12/22

https://www.climatechangepost.com/europe/agriculture-and-horticulture/

- Countryside, 2020. Our guide to British horticulture. Countryside is a membership category of the National Farmers' Union (NFU), viewed 07/12/22, <a href="https://www.countrysideonline.co.uk/food-and-farming/feeding-the-nation/horticulture/">https://www.countrysideonline.co.uk/food-and-farming/feeding-the-nation/horticulture/</a>
- CSO, 2016, Farm Structure Survey. Central Statistic Office, viewed 07/12/22, <u>https://www.cso.ie/en/releasesandpublications/ep/pfss/farmstructuresurvey2016/da/lu</u> <u>/#:~:text=There%20was%20almost%204.9%20million,Rough%20Grazing%20(16%2</u> <u>C300%20hectares</u>)



CSO, 2019, Statistical Yearbook of Ireland 2019, Agriculture Accounts and Prices. Central Statistic Office, viewed 07/12/22, https://www.cso.ie/en/releasesandpublications/ep/psyi/statisticalyearbookofireland20

https://www.cso.ie/en/releasesandpublications/ep/psyi/statisticalyearbookofireland20 19/agri/agpr/

- CSO, 2020, Environmental Indicators Ireland 2020. Central Statistic Office, viewed 07/12/22 https://www.cso.ie/en/releasesandpublications/ep/peii/environmentalindicatorsireland 2020/landuse/
- CSO, 2021, Environmental Indicators Ireland 2021. Central Statistic Office, viewed 07/12/22 <u>https://www.cso.ie/en/releasesandpublications/ep/peii/environmentalindicatorsireland</u> <u>2021/landuse/#:~:text=Grassland%20accounted%20for%2059.3%25%20of,settleme</u> <u>nt%20was%201.8%25%20in%202019</u>.
- CSO, 2022a, Agricultural Price Indices April 2022. Central Statistic Office, viewed 07/12/22 <u>https://www.cso.ie/en/releasesandpublications/epapi/agriculturalpriceindicesapril2022</u>
- CSO, 2022b, 'Fertiliser Price (Euro per Tonne), Agricultural Input and Output', Absolute Prices. AJA05. Central Statistic Office, viewed 07/12/22 <u>https://data.cso.ie/table/AJA05</u>
- CSO, 2022c. Fertiliser Sales 2021. Fertiliser sales increased by 6% in 2021 with nitrogen content up 5%. CSO statistical publication. Online ISSN: 2811-5767. Central Statistic Office, viewed 30/11/22,

https://www.cso.ie/en/releasesandpublications/ep/p-fsa/fertilisersales2021/

- CSO, 2022d. Area Farmed in June- AQA06, Agriculture Area Used and Crop Production, Central Statistics Office, viewed 01/02/22 <u>https://data.cso.ie/</u>
- de Buck, A.J., van Dijk, W., van Middelkoop, J.C., Smit, A.L., van Reuler, H. & Evers, A. 2012. Agricultural scenarios to reduce the national phosphorus surplus in the Netherlands, Praktijkonderzoek Plant & Omgeving (Applied Plant Research), part of Wageningen UR, viewed 07/12/22 <u>https://edepot.wur.nl/247486</u>
- Deloitte Sustainability, (2017). 'Study on the review of the list of Critical Raw Materials 2017', British Geological Survey, Bureau de Recherches Géologiques et Minières and Netherlands Organisation for Applied Scientific Research, European Commission, 1-9.
- Dillon, E., Buckley, C., Moran, B., Lennon, J. & Wall, D. Teagasc National Farm Survey 2005-2015, viewed 07/12/22, <u>https://www.teagasc.ie/media/website/publications/2018/Fertiliser-Use-Survey---</u> 290518.pdf
- Egan, A., Saju, A., Sigurnjak, I, Meers, E, Power, N., 2022. 'What are the desired properties Of recycling-derived fertilisers from an end-user perspective?'. Cleaner and Responsible Consumption, Volume 5, 2022. https://doi.org/10.1016/j.clrc.2022.100057
- Enterprise Ireland, 2022. Food Investment from Outside Ireland. Key Sectors on Horticulture. Enterprise Ireland. viewed on 07/12/22 <u>https://www.enterpriseireland.com/en/start-a-business-in-ireland/food-investment-from-outside-ireland/keysectors/horticulture/horticulture.html#:~:text=Mushroom%20exports%20to%20the%2 0UK,%2C%20Cavan%2C%20Tipperary%20and%20Mayo.</u>
- EPA, 2022a. Current trends in land and soil. Environmental Protection Agency, viewed 07/12/22<u>https://www.epa.ie/our-services/monitoring--</u> assessment/assessment/irelands-environment/land--soil/current-trends-landandsoil/#:~:text=The%20most%20recent%20assessment%20(CORINE,%25)%20an d%20forestry%20(9.5%25)
- EPA, 2022b. Greenhouse Gas Emissions. Key messages taken from the IPCC's 5th



Assessment Report (AR5). Environmental Protection Agency, viewed 30/11/22, https://www.epa.ie/our-services/monitoring--assessment/climate-change/ghg/keymessages/

- EC, 2022. Ensuring availability and affordability of fertilisers. Measures to maintain a sustainable European fertilisers' production, optimise use and reduce dependency on mineral fertilisers. Agriculture and rural development. European Commission, viewed 06/12/22. https://agriculture.ec.europa.eu/common-agricultural-policy/agri-foodsupply-chain/ensuring-availability-and-affordability-fertilisers en#documents
- EC, 2019a. Live plants and flowers. Agriculture and rural development. European Commission viewed on 24/10/22, https://agriculture.ec.europa.eu/farming/cropproductions-and-plant-based-products/live-plants-and-flowers en.
- EC, 2019b. 'Fertilisers in the EU. Prices, trade and use', EU Agricultural Markets Briefs No 15. European Commission, viewed on 07/12/22 https://ec.europa.eu/info/sites/default/files/food-farmingfisheries/farming/documents/market-brief-fertilisers june2019 en.pdf
- EC, 2014. 'Communication from the Commission to the European Parliament the Council, the European Economic and Social Committee and the Committee of the Regions', Review of the List of Critical Raw Materials for the EU, European Commission, Brussels.
- European Parliament, 2019. The EU fruit and vegetable sector. Main features, challenges and prospects. European Parliamentary Research Service (EPRS), viewed on 07/12/22

https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/635563/EPRS BRI(201 9)635563 EN.pdf

- European Parliament, 2014. On the future of Europe's horticulture sector, strategies for growth. Report - A7-0048/2014 European Parliament, viewed on 07/12/22, https://www.europarl.europa.eu/doceo/document/A-7-2014-0048 EN.html
- European Plant Science Association, 2013. Horticulture Research in Europe- to 2020 and beyond. EPSO White paper, viewed on 07/12/22 https://eufrin.eu/fileadmin/user upload/EPSO-WG-Hort White-Paper July2015.pdf
- Eurostat, 2021a, Tenure of agricultural holdings, Management and practices', Eurostat- high quality statistics and data on Europe, viewed on 16/11/22,

https://ec.europa.eu/eurostat/databrowser/view/ef mp tenure/default/table?lang=en

- Eurostat, 2021b. Land use overview by NUTS 2 region', Land cover and land use, landscape (LUCAS). Eurostat- high quality statistics and data on Europe, viewed on 13/10/22 https://ec.europa.eu/eurostat/databrowser/view/lan\_use\_ovw/default/table?lang=en
- Eurostat, 2021c. Sales of fertilisers by type of nutrient (source: Fertilizers Europe) [TAI01]. Estimated quantity of fertilizer sold, per nutrient. Eurostat- high quality statistics and data on Europe. The data has been discontinued from 07 Apr 2022.
- Eurostat, 2022a. Gross nutrient balance [AEI PR GNB custom 2112710]. Nutrient inputs per hectare UAA (kg of nutrient per ha). Eurostat- high quality statistics and data on Europe, viewed on 16/11/22

https://ec.europa.eu/eurostat/databrowser/view/aei pr gnb/default/table?lang=en

- Eurostat, 2022b, Farm indicators by agricultural area, type of farm, standard output, legal form and NUTS 2 regions [EF\_M\_FARMLEG\_\_custom\_3000123]. Eurostat- high quality statistics and data Europe, viewed 17/11/22 on on https://ec.europa.eu/eurostat/databrowser/view/EF M FARMLEG custom 206132/ default/table?lang=en
- Eurostat, 2022c. Farms and farmland in the European Union statistics. Eurostat Statistics Explained. Eurostat- high quality statistics and data on Europe, viewed on 02/12/22, https://ec.europa.eu/eurostat/statistics-

explained/index.php?title=Farms and farmland in the European Union - statistics



- Eurostat, 2022d. Mineral fertiliser consumption remained high in 2020. Products Eurostat News. Eurostat- high quality statistics and data on Europe, viewed on 02/12/22 <u>https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220628</u> <u>1#:~:text=The%20amount%20of%20mineral%20fertilisers,8.3%25%20increase%20c</u> <u>ompared%20with%202010</u>
- European Union Commission Regulation (EU) 2016/2066 of 21 November 2016 amending the annexes to Regulation (EC) No 1059/2003 of the European Parliament and of the Council on the establishment of a common classification of territorial units for statistics (NUTS), viewed on 01/12/22, <u>https://eur-lex.europa.eu/legalcontent/EN/TXT/?toc=OJ:L:2016:322:TOC&uri=uriserv:OJ.L .2016.322.01.0001.01.E</u> NG.
- Federal Ministry of Food, 2016. Horticulture Made in Germany. Federal Ministry of Food, and Agriculture (BMEL), viewed on 07/12/22, <u>https://www.bmel-statistik.de/fileadmin/daten/GBB-0000502-2016.pdf</u>
- Fernández, L., 2021, 'Fertilizer market size worldwide 2020-2027', *Chemicals & Resources*, Chemical Industry. Statista. Eurostat, viewed on 07/12/22, https://data.europa.eu/data/datasets/oba8ifzvim0lhjkzm8moyg?locale=en
- France 24, 2021. Rising fertiliser prices may prompt French farmers to switch grain crops. REUTERS, viewed on 07/12/22, <u>https://www.france24.com/en/france/20211014-rising-fertiliser-prices-may-prompt-french-farmers-to-switch-grain-crops</u>
- French Farming, 2021. France loses 20 percent of farms as large-scale agriculture gains ground. Radio France Internationale, viewed on 27/01/23 https://www.rfi.fr/en/france/20211210-france-loses-20-percent-of-farms-as-largescale-agriculture-gains-ground
- Garside, M., 2021. Distribution of global potash reserves by select country 2019, Chemicals & Resources, Mining, Metals & Minerals, Statista, viewed on 07/12/22 <u>https://www.statista.com/statistics/604174/distribution-of-potashreserves-worldwide-by-select-country/</u>
- Cockerill, R., 2021. CO2: Fertiliser plant closures confirmed, more expected. Gas World, viewed on 07/12/22 <u>https://www.gasworld.com/co2-fertiliser-plant-closures-expected/2021734.article</u>
- Ibis World, 2021. Fertiliser & Nitrogen Compound Manufacturing in Germany Market Research Report. Industry Research Reports -Germany, viewed on 07/12/22, <u>https://www.ibisworld.com/germany/industry/fertiliser-nitrogen-compound-manufacturing/747/</u>

IndexBox, 2002. EU Nitrogen Market Report: Production, Exports, Imports, and Forecast to 2030. GlobeNewswire, viewed on 07/12/22, <u>https://www.globenewswire.com/en/newsrelease/2022/05/30/2452407/0/en/EU-</u><u>Nitrogen-Market-Report-Production-Exports-Imports-and-Forecast-to-2030-</u><u>IndexBox.html#:~:text=The%20Netherlands%20represented%20the%20key,of%20to</u> <u>tal%20supplies%20in%202021</u>

- International Society for Horticultural Science (ISHS), 2022. Horticulture Research International, Belgium, viewed on 07/12/22, <u>https://www.hridir.org/countries/belgium/index.htm</u>
- Lëtzebuerg,Farming Portal, 2022. De Beroder, Numbers 65 to 106. Price Statistics from 2010 to 2021, viewed on 30/11/22, https://agriculture.public.lu/de/publications.html?g=Preisstatistik.

Lloyds Bank. Economic Indicators, The economic context of Luxembourg. Luxembourg: Economic and Political Overview, viewed on 01/12/22, <u>https://www.lloydsbanktrade.com/en/market</u><u>potential/luxembourg/economical-</u> context



- Lory, G., 2022. Skyrocketing fertiliser prices sends farmers production costs soaring. Euro News, viewed on 17/11/22, <u>https://www.euronews.com/my-europe/2022/03/21/skyrocketing-fertiliser-prices-sends-farmers-production-costs-soaring</u>
- Moran, C., 2021. Fertiliser sales up 25pc despite efforts to curb usage. Farming Independent, viewed on 07/12/22, <u>https://www.independent.ie/business/farming/news/farming-news/fertiliser-sales-up-25pc-despite-efforts-to-curb-usage-40464809.html</u>
- Nations Encyclopedia, 2012, Luxembourg Agriculture. Encyclopedia of the Nations, viewed on 07/12/22, <u>https://www.nationsencyclopedia.com/economies/Europe/Luxembourg-AGRICULTURE.html</u>
- Nature Rising, 2022. The Dutch Horticulture Industry. Nature Rising, the Climate and Biodiversity Campaign, viewed on 07/12/22, https://naturerising.ie/the-dutch-horticulture-industry/
- Nutriman, 2020. Fertilizers: Something new in France and Europe. NUTRIMAN NUTRIent MANagement and Nutrient Recovery Thematic Network, viewed on 07/12/22, https://nutriman.net/news/fertilizers-something-new-france-and-europe
- O'Brien, B., 2018. 2018 fertiliser prices to remain above last year's levels, Agriland Media Company, viewed on 07/12/22, <u>https://www.agriland.ie/farming-news/fertiliser-prices-to-remain-above-last-years-levels/</u>
- O'Donnell C, Barnett D, Harrington J and Power N., 2022. 'The extended effect of topdressed recovered struvite fertiliser on residual Irish grassland soil Phosphorus levels compared to commercial Phosphorus fertiliser'. Agronomy, 12(1):8. https://doi.org/10.3390/agronomy12010008
- Organisation for Economic Cooperation and Development (OECD). 2020. Taxation in Agriculture, Organisation for Economic Cooperation and Development OECD Publishing, Paris, viewed on 31/01/23 <u>https://www.oecd-ilibrary.org/sites/33386d69-en/index.html?itemId=/content/component/33386d69-en</u>
- PhosAgro, 2012. Delivering stable growth and sustainable returns. Annual Report. PhosAgro is a vertically integrated Russian company and one of the world's leading phosphate-based fertilizer producers, viewed on 07/12/22, <u>https://www.annualreports.com/HostedData/AnnualReportArchive/p/LSE\_PHOR\_201</u> 2.pdf
- Polansek, T. and Mano, A., 2022. As sanctions bite Russia, fertilizer shortage imperils world food supply, Business, Reuters, viewed on 07/12/22, <u>https://www.reuters.com/business/sanctions-bite-russia-fertilizershortage-imperils-</u> world-food-supply-2022-03-23/
- Reiter, M. 2020. Conversion Factors Needed for Common Fertilizer Calculations, Eastern Shore Agricultural Research and Extension Center, Virginia Tech, viewed on 27/10/22, <u>https://www.pubs.ext.vt.edu/content/dam/pubs\_ext\_vt\_edu/spes/spes-201/SPES-201.pdf</u>
- Rossi, R., 2019. The EU fruit and vegetable sector. Main features, challenges and prospects. European Parliamentary Research Service (EPRS).Members' Research Service PE 635.563, viewed on 07/12/22, <u>https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/635563/EPRS\_BRI(201</u> 9)635563 EN.pdf
- Roy, A., 2022. Europe Organic Fertilizer Market by Source (Plant, Animal, and Mineral), by Crop Type (Cereal & Grain, Oilseed & Pulse, Fruit & Vegetable, and Others), by Form (Dry and Liquid) and by Country (Germany, France, Italy, Spain, UK, and Rest of Europe) - Opportunity Analysis and Industry Forecast, 2017-2023, Allied Market Research.



- Stanisławska-Glubiak, E.,Korzeniowska, J.,Hoffmann, J., Górecka, H., Jóźwiak, W. & Wiśniewska, G., 2014. Effect of sulphur added to phosphate rock on solubility and phytoavailability of phosphorus. Polish Journal of Chemical Technology. 16, 1, 81 — 85, 10.
- Statbel, 2021. Agricultural lands and forests account for two thirds of the Belgian territory. StatBel, Belgium in Figures, viewed on 07/12/22, <u>https://statbel.fgov.be/en/themes/environment/land-cover-and-use/land-use#:~:text=Agricultural%20lands%20account%20for%2044,used%20for%20transports%20and%20communications.</u>

Statbel, 2022. Agricultural prices. StatBel, Belgium in Figures, viewed on 07/12/22, https://statbel.fgov.be/en/themes/agriculture-fishery/agricultural-prices

- Statista, 2019. Breakdown of land use in France in 2019. Agriculture Statistics. Statista, statistical portal for market research, viewed on 07/12/22 <u>https://www.statista.com/statistics/1104997/land-use-in-</u> <u>france/#:~:text=Land%20use%20in%20France%202019&text=A%20majority%20of%</u> 20the%20land,soil%20transformed%20for%20infrastructure%20construction.
- Statista, 2022. Agricultural fertilizer market in the UK statistics & facts. Statista, statistical portal for market research, viewed on 07/12/22, <u>https://www.statista.com/topics/4588/agricultural-fertilizer-market-in-the-uk/#dossierKeyfigures</u>
- Statistisches Bundesamt, 2022a. Good apple yield expected for 2022: ten-year average likely to be exceeded by 8.2%. Statistisches Bundesamt- German Federal Statistical Office, viewed on 07/12/22, <u>https://www.destatis.de/EN/Themes/Economic-Sectors-Enterprises/Agriculture-Forestry-Fisheries/Fruit-Vegetables-Horticulture/ node.html#265410</u>
- Statistisches Bundesamt, 2022b. Agriculture and forestry, fisheries. Wine Statistisches Bundesamt- German Federal Statistical Office, viewed on 07/12/22, <u>https://www.destatis.de/EN/Themes/Economic-Sectors-Enterprises/Agriculture-Forestry-Fisheries/Wine/ node.html</u>
- StatLine, 2022. Agriculture; crops, animals, land use and labour at the national level. Horticulture statistics for the Netherlands, viewed on 07/12/22, https://opendata.cbs.nl/#/CBS/nl/dataset/81302ned/table?dl=6AD39
- Succop, E. & Newman, S., 2004. Organic Fertilization of Fresh Market Sweet Basil in a Greenhouse, HortTechnology, 14 (2) 235-239.
- Tanabe, Y. and Nishibayashi, Y., 2013. 'Developing more sustainable processes for<br/>Ammonia synthesis', Coord. Chem. Rev. 257 (17–18).<br/>https://doi.org/10.1016/j.ccr.2013.02.010.
- Teagasc, 2019, Fruit Production in Ireland. Teagasc- Agriculture and Food Development Authority, viewed on 07/12/22,

https://www.teagasc.ie/crops/horticulture/fruit-production/

- Teagasc 2021. Unearthing the value of Irish fruit and vegetables. TResearch Autumn/Winter 2021. Teagasc- Agriculture and Food Development Authority, viewed on 01/12/22, <u>https://www.teagasc.ie/about/research--innovation/researchpublications/tresearch-autumn-winter-2021/unearthing-the-value-of-irish-fruit-andvegetables/</u>.
- World Bank, 2022. Pink Sheet Data (May 2022), Commodity Markets, viewed on 07/12/22, https://www.worldbank.org/en/research/commodity-markets
- Trading Economics, 2022. Netherlands Imports of Fertilizers. Trading Economics, viewed on 07/12/22, https://tradingeconomics.com/netherlands/imports/fertilizers



- UK Parliament, 2022. The UK's horticultural sector. House of Lords Library, UK Parliament, viewed on 07/12/22 <u>https://lordslibrary.parliament.uk/the-uks-horticultural-sector/#:~:text=Horticulture%20is%20the%20sector%20of,%C2%A35%20billion%20</u>each%20year.
- VLAM, 2022. Flanders' Agricultural Marketing Board. Why Belgian Ornamental Horticulture? VALM, the Flemish Center for Agro and Fisheries Marketing, viewed on 07/12/22 https://www.belgianplants.com/en
- Wageningen University, 2022. Agro & food portal. Agricultural prices, Wageningen University, viewed on 07/12/22, <u>https://www.agrimatie.nl/Prijzen.aspx?ID=15125</u>
- WDC Insights, 2018. Nuts about NUTS! WDC Insights providing insights on key issues for the Western Region of Ireland. Western Development Commission (WDC) Policy Analysis Team, viewed on 01/12/22, https://wdcinsights.wordpress.com/2018/07/03/nuts-about-nuts/
- WillAgri, 2019. Downward Trend for Sales of Fertiliser in France. Agriculture Blog, viewed on 07/12/22, <u>https://www.willagri.com/2019/12/11/downward-trend-for-sales-of-fertiliser-in-france/?lang=en</u>
- Yara, 2022. Corporate Releases, Yara implements further production curtailments in Europe. Yara International, viewed on 07/12/22, <u>https://www.yara.com/corporate-releases/yara-implements-further-production-curtailments-in-europe/</u>