



Apple production and apple value chains in Europe

A. Muder¹, H. Garming¹, S. Dreisiebner-Lanz², K. Kerngast², F. Rosner³, K. Kličková⁴, G. Kurthy⁵, K. Cimer⁵, A. Bertazzoli⁶, V. Altamura⁷, G. De Ros⁸, K. Zmarlicki⁹, M. de Belém Costa Freitas¹⁰, A. Duarte¹⁰, E. Bravin¹¹, J. Kambor¹¹, D. Karamürsel¹², F. Pınar Öztürk¹² and E. Kaçal¹²

¹ Thünen-Institute of Farm Economics, Braunschweig, Germany

² Joanneum Research Forschungsgesellschaft mbH, LIFE – Institute for Climate, Energy and Society, Graz, Austria

³ Höhere Bundeslehranstalt und Bundesamt für Wein- und Obstbau Klosterneuburg, Klosterneuburg, Austria

⁴ Institute of Agricultural Economics and Information, Praha, Czech Republic

⁵ Institute for Agricultural Economics, Budapest, Hungary

⁶ DISTAL – University of Bologna, Bologna, Italy

⁷ Crop Production Research Centre (C.R.P.V.), Cesena, Italy

⁸ Technology Transfer Centre; Fondazione Edmund Mach (FEM), San Michele all'Adige, Italy

⁹ Instytut Ogródnictwa - PIB / The National Institute for Horticultural Research, Skierniewice, Poland

¹⁰ Algarve University, MED - Mediterranean Institute for Agriculture, Environment and Development, Faro, Portugal

¹¹ Agroscope, Wädenswil, Switzerland

¹² Fruit Research Institute, Eğirdir/Isparta, Turkey

Summary

This paper presents an overview of the apple sector in nine major apple producing countries in Europe, in order to assess factors for the competitiveness of the national apple value chains and identify challenges for the future development of the sector. Based on international and national statistical data and expert assessment, key characteristics of apple production and value chains are analyzed. For each country, a brief description of the development of apple production and acreage over the past ten years, farm size distribution, level of production technology and main market channels is presented, followed by a discussion of differences and similarities. Results show a diverse picture of the apple sector in Europe. Similarities are observed in the existence of regional production clusters and a generally small farm size. Differences are found in the technology level, with a broad range of very traditional extensive production systems up to highly intensified orchards with high tree density. All countries experienced high fluctuation in apple production quantities over the past years, mainly due to weather events, particularly spring frost and drought, and climate risks are expected to increase in the future, leading to increasing costs for mitigation measures.

Keywords

competitiveness, economics of horticulture, farm structures, fruit production, international trade flows, production systems

Introduction

Problem statement

Apples are one of the most important fruits world-wide and ranked, based on the volume of production, third, after bananas and watermelons in 2019 (FAO, 2021). Due to their adaptation to temperate climate, they are produced on the

Significance of this study

What is already known on this subject?

- There is a research gap concerning comparable and systematic analyses of the farm structures and value chains of the apple sector in major European producing countries.

What are the new findings?

- The study finds diverse apple farm structures and value chains in the study countries, and identifies framework conditions that are major drivers of the development of the sector. While climate change is a common challenge for apple production in all study countries, the technology level, market conditions and public support to the sector differ largely, leading to specific challenges for the national apple sectors.

What is the expected impact on horticulture?

- Understanding farm structures and market characteristics of the apple sector forms an important base for further investigations concerning economic analysis, climate change impact and competitiveness assessment of the sector. This basic research is highly needed for further economic in-depth analysis.

Northern as well as on the Southern Hemispheres. Fruit consumption globally is increasing not only with population growth but also per capita consumption has increased, e.g., by 27 % since 2000 (FAO, 2021). This can be attributed to an increasing demand for tasty and healthy food as incomes are rising and fruits and vegetables become affordable for more people in most countries of the world (United Nations, 2015), but might as well be related to increasing yields through intensification of fruit production systems. With the Sustainable Development Goals (SDGs) the United Nations set the target to end all forms of hunger and malnutrition by 2030 (United Nations, 2015). Fruits play an important role to achieve this objective as they deliver important micronutrients and vitamins, what makes them an essential compo-

ment for a healthy diet. FAO and WHO (2004) recommend an intake of at least 400 g fruits and vegetables per person and day. Due to the predicted world population growth from today 7.7 billion to 9.7 billion people until 2050 (United Nations, 2019) the demand for fruits will considerably increase further.

Most European countries have favorable conditions for the cultivation of apples and several EU-member states are major players on the world apple market. Since large proportions of apples are traded internationally, the competitive pressure on the global market is high. The share of small farms of European apple production is still considerable with average fruit production acreage per holding between 0.5 ha to 5 ha in most EU member countries (Eurostat, 2020), although structural change towards fewer and larger farms is going on continuously. Not only the structures of fruit producing farms are changing, apple production systems in Europe are also undergoing significant changes. Innovations in planting and trellising systems as well as varieties and crop management lead to increasing productivity. Also, new technologies for mechanization of crop management and harvest, for grading and long-term storage have impacts on the apple market and on the competitiveness of different regions within Europe. However, increased production risk due to climate change leads to higher volatility in production. At the same time, apple producers are exposed to different framework conditions with respect to environmental legislation (Menghi et al., 2015), access to and support for risk management such as subsidies for hail insurances or protection measures, differences in the wage level as well as the access to working forces from abroad (Schwartau, 2018). This leads to different levels of competitiveness that affect apple value chains and their efficiency.

Overview about apple production in Europe and the World

World apple production has developed dynamically over the past 20 years. Between 2000 and 2014, global apple production has increased by 44%, with a continuous growth between 2002 and 2014 (FAO, 2021) (Figure 1). Since then, however, production has not further increased but varies between 82 and 87 million tons of apples per year. Major ap-

ple producing countries are China (42.43 million tons) and the U.S.A. (5.00 million tons), based on data from 2019 as a reference. Turkey and Poland ranked place 3 and 4, with 3.62 million tons and 3.08 million tons, respectively. Italy, the second largest producer of apples in the EU, harvested 2.30 million tons and hence ranks 6th after India with 2.32 million tons (FAO, 2021).

Productivity, as measured by yield per hectare ($t\ ha^{-1}$), does not seem to be correlated with total production. None of the top five producers in terms of quantities is also among the top five with respect to yields, which are Switzerland ($59.11\ t\ ha^{-1}$), New Zealand ($53.15\ t\ ha^{-1}$), Chile ($50.17\ t\ ha^{-1}$), Belgium ($45.7\ t\ ha^{-1}$) and Italy ($42.9\ t\ ha^{-1}$), based on FAO data (FAO, 2021).

While global production was increasing between 2002 and 2014, the share of apples from European production decreased from about 30% in 2000 to only 19% in 2010. Since then, apple production in Europe increased again and its share of global apple production varied between 24% and 17%. The effect of volatile climate conditions on apple production is visible even in this highly aggregated overview, e.g., with exceptionally low production in 2017, where spring frosts damaged apple flowers throughout Europe, and a recovery in 2018 (Figure 1).

Comparing global apple production and global apple export data shows that about 10% of apple harvest is exported as fresh apples (FAO, 2020; UN Comtrade, 2020). Few countries supply the bulk of apples to the international markets, based on competitiveness of apple production and infrastructure for exports. Figure 2 illustrates the trade flows, where major exporting countries and their top 3 to 5 trade partners are shown. China ranks first in both, apple production as well as export of fresh apples and export of juice or concentrated juice (UN Comtrade, 2021).

In 2018, about 19.6 million tons of apples were produced on an area of 1 million ha in Europe. Eastern European countries account for a major share of apple production and account for 76% of apple cultivation area and 58% of European apple harvest. Table 1 shows the top twenty European apple producers by acreage, including Turkey and Russia.

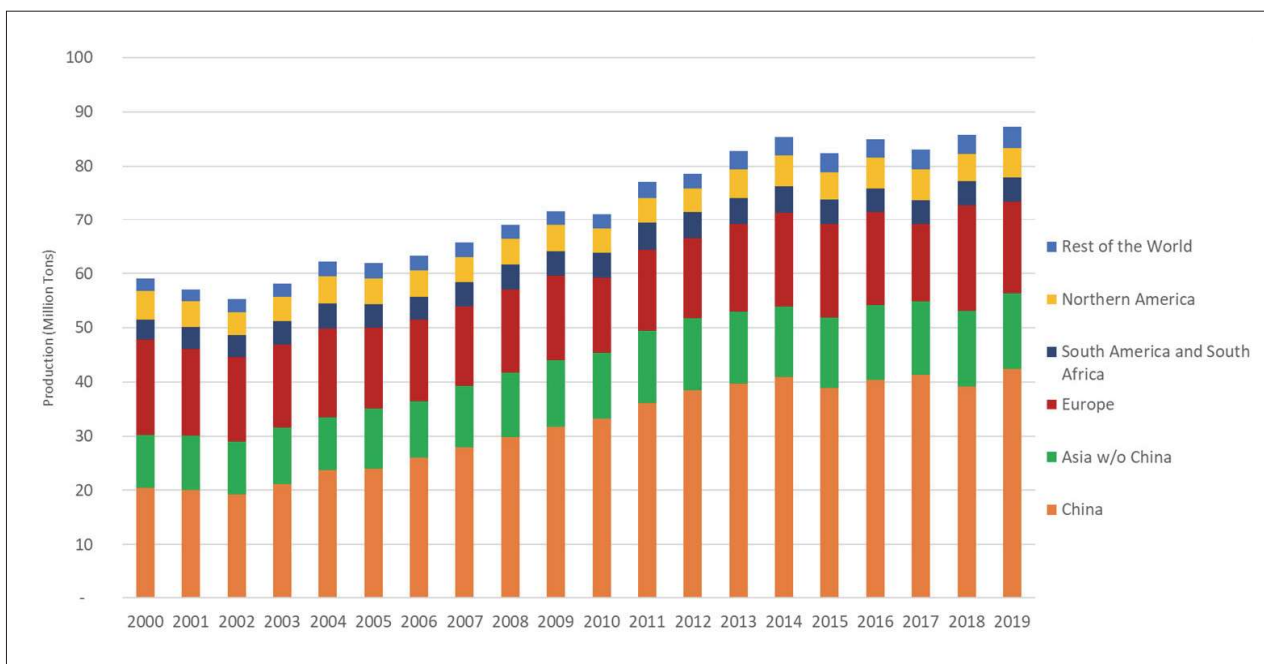


FIGURE 1. Global apple production, 2000–2019. Source: FAO (2021).

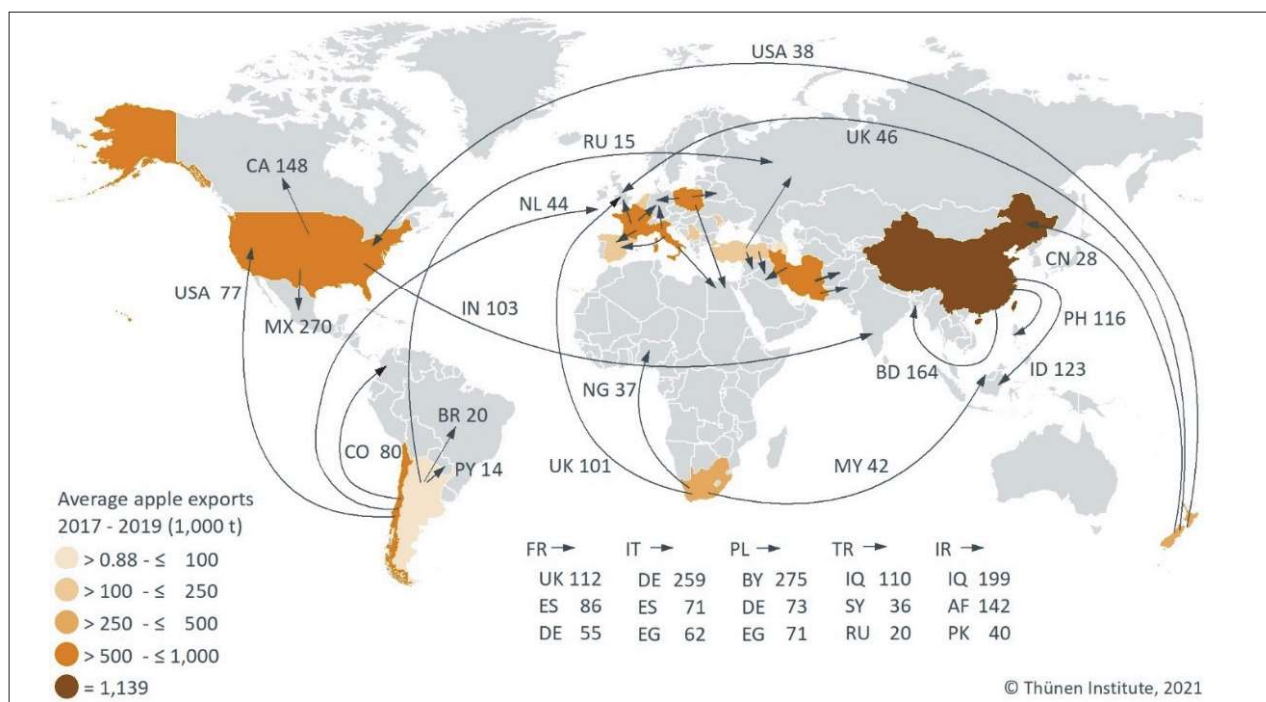


FIGURE 2. Export destinations and quantities of major apple exporting countries for fresh apples*. Source: UN Comtrade (2020). Data and map: esri (2019).

* Total average exports 2017–2019 (1,000 tons): US: 891, CH: 722, AR: 93,5, ZA: 490, PL: 903, IT: 885, FR: 509, NZ: 368, CN: 1,139, IR: 515, TR: 233.

Literature review

Apples are among the most cultivated and consumed fruits in many countries around the world (FAO, 2020). Information on apple production and trade is available in official statistics and reports on global level through the FAO crop production statistics and the UN Comtrade database. Since February 2020 the Food and Agricultural Organization of the United Nations

provides a food price monitoring tool with daily surveys for 14 basic products, including apples (FAODataLab., 2021). Furthermore, for Europe there are statistics on the European Commission’s website on apple prices, areas and yields (European Commission, 2020a). National agricultural statistics include data on apple production, yields, regional clusters and farm structures in all major apple producing countries.

TABLE 1. Top 20 apple producing countries in Europe by acreage in 2018. Source: FAO (2021).

Country	Acreage (ha)	Production (t)	Yield (t ha ⁻¹)
Europe	1,161,269	19,659,204	19.5
Russian Federation	211,164	1,859,400	9.2
Turkey	174,439	3,618,752	20.7
Poland	155,620	3,080,600	19.8
Ukraine	87,700	1,153,970	13.2
Italy	55,000	2,303,690	41.9
Romania	52,740	492,700	9.3
Belarus	51,537	336,697	6.5
Republic of Moldova	51,537	610,921	11.9
France	50,370	1,753,500	34.8
Germany	33,980	991,450	29.2
Bosnia and Herzegovina	32,566	98,265	3.0
Hungary	30,970	498,330	16.1
Spain	29,640	638,840	21.6
Serbia	26,089	499,578	19.1
United Kingdom	15,963	609,180	38.2
Portugal	14,310	370,710	25.9
Lithuania	10,180	32,070	3.2
North Macedonia	10,112	88,701	8.8
Greece	9,820	277,110	28.2
Czechia	7,320	99,500	13.6

In order to summarize statistical data and make information easily available to the stakeholders of the apple value chain, global or regional overviews of the world apple market are published periodically, e.g., by the U.S. department of Agriculture, which publishes a biannual world market report, covering production, consumption, stocks, developments and trade in apples, grapes and pears (USDA, 2020). Additionally, for the U.S. major trading partners, annual fruit reports are published such as for China (e.g., GAIN, 2020a), for the EU (e.g., GAIN, 2020b), and for Russia (e.g., GAIN, 2020c). Also, the economic board of the fruit and vegetables market observatory subgroup on pip fruits of the European Commission publishes presentations and reports of their biannual meetings (European Commission, 2020b). These focus on recent developments of the sector. Beside these official statistics and reports there are a few studies on specific aspects of the apple value chains and the apple producing sectors in specific countries. Such analyses address questions such as the competitiveness of the industry, efficiency of value chains or the adaptation of the sector to new challenges. In this section, we give an overview of recent literature addressing important aspects in different countries.

Vasylieva and James (2021) used FAO statistical data to analyze production and trade patterns on the world apple market by clustering countries and investigating their capacities and prices. They distinguished groups of countries with apple production according to their focus on domestic markets, export markets or competition with imports, using the relation of producer prices to the import or export prices of apples as indicator. Jafta (2014) considered the South African apple industry and analyzed the competitiveness of the sector, by calculating comparative and competitive advantage indices and applying the Porter model, Pietrzak et al. (2020) applied the concept of global value chains for their analysis of the Polish apple sector, while Apáti (2009) focused on comparing farm level profitability between Hungarian and German apple farms. Relevant aspects for the analysis of competitiveness and the development of the national apple production sector are thus international trade and trade policies (Retamales and Sepúlveda (2011) for Chile, Jafta (2014) for South Africa and Blanke (2021) for the Russian Federation) as well as the organization and efficiency of domestic value chains (Pietrzak et al. (2020) for Poland, Oğuz and Karaçayır (2009) for Turkey). Other studies focused on production related factors such as the size and structure of fruit farms, the portfolio of apple varieties, production conditions, cost of production and farm level profitability (Żurawicz et al. (2019) for Poland, Ekinci et al. (2020) for Turkey, Lang and Prantl (2018) for Italy, Gooch et al. (2012) for Canada).

Climate change increasingly affects apple production and the competitiveness of the sector in many countries. Blanke (2017) focused on the effects of climate change on the Brazilian apple production and found increasingly challenging conditions due to a lack of chilling effects in winter and growing fruit damages caused by hail. Wurm (2021) considered fruit production in Austria under changing framework conditions and pointed out that climate change have also a great impact on Austrian apple production, namely due to an earlier start of the vegetation cycle. He furthermore accounts for loss of production area due to sealing, new introduced plant diseases and pests, societal challenges and the advancing globalization.

The reviewed studies shed light on certain individual aspects in single countries and are important to provide a detailed insight into the apple sector in the respective coun-

tries. Comparative analyses between neighboring and competing apple producing countries can provide a better understanding to the structure and developments of the apple sector; to analyze competitiveness and to identify specific challenges for the industries. However, a general approach with a consistent methodology, which allows comparisons between countries is still missing.

To close the existing research gap, we aim to provide a systematic basic overview of the apple sector in nine European countries, which will allow cross-country comparisons of the apple sector structures. The countries included in this overview span a broad geographical range from Eastern to West Europe, include EU members and non-members, and represent a broad variation of climatic conditions from Northern maritime (Northern Germany) and continental (Poland, Czech Republic, Hungary) climate, the alpine region (Austria, Switzerland, Northern Italy) to the Mediterranean (Portugal, Turkey). The primary data base of this overview consists in national statistics. Our elaboration will build an important base for the further consideration of the European apple market, to assess the competitiveness of the sector and to derive future prospects.

Research objective

This study aims at providing an overview about the apple sector in various countries and describes their production structures and the basic market and policy setting. Major differences between the countries are highlighted and research needs are identified. A focus of the paper will lie on farm structures, main production regions, cultivated varieties and trade relations. As a joint effort of experts from various countries, the access to national statistics and practical expert knowledge is ensured and language barriers are overcome. The remainder of the paper is organized as follows: In the next section, data sources and indicators are briefly explained. The result section presents specific insights on apple production and farm structures from selected countries, based on the experience and expertise of the co-authors from Austria, Czechia, Germany, Hungary, Italy, Poland, Portugal, Switzerland and Turkey. The discussion section summarizes main results and identifies differences and parallels in the apple sectors of these countries, and finally conclusions are drawn.

Materials and methods

This study combines an analysis of available national and international statistics on apple production and trade, a literature review and an assessment of the apple production sector by national experts from all included countries. The data collection procedure followed a two-stage process. In the first step, recent literature was scanned and data from international statistics were collected in order to identify the most important players on the European apple market as well as to identify current events and trends that are affecting the market. In the second step, data from national and regional statistics were collected and compiled for in each of these countries. The establishment of a panel of experts from very different countries reflecting the various conditions of apple production in Europe. However, the available data in the countries also vary a lot. Therefore, this study focused on official data sources and statistics for a valid comparison and to create a good reference for further, more detailed investigations. The data were analyzed with a focus on general statistical characteristics, apple producing regions, varieties and marketing channels as well as trade, following a jointly defined structure and categories to make results compara-

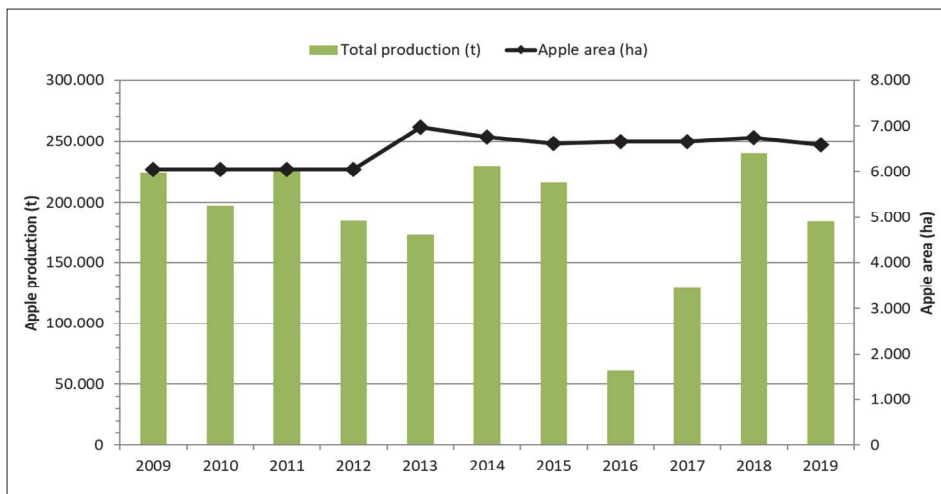


FIGURE 3. Total apple production and area 2009–2020 in Austria. Source: Statistik Austria.

ble. Important variables that were considered are: total apple production, apple production area, farm size, share of varieties and import and export quantities. The data analysis is complemented by qualitative assessment of the challenges of the national apple sectors by experts from all countries covered in this paper. Finally, an attempt is made to identify similarities and differences that are assumed to contribute to competitiveness of the apple production sector.

Results

AUSTRIA

Statistical overview

In the course of the agriculture census 2017 in Austria, an area of 15,700 ha of fruit was recorded, which corresponds to an increase of 15% compared to the data in 2007. Thereof, 7,700 ha accounted for apple production, which corresponds to 49% of the total area. The number of fruit farmers decreased by 7% compared to 2007 and amounted to 3,909 farms. This downward trend was already observed in the comparison of 2007 and 1997 and reflects the general trend in Austrian agriculture: the number of farms decreases and farms become larger. The farms that grow apples were 1,932 in 2017 (Statistik Austria, 2018).

The repeated spring frost events in 2016, 2017, 2019 and 2020 had a strong yield-limiting effect depending on the variety, and alternate bearing effects were also partly responsible for lower yields (Figure 3). In 2020, apple harvest achieved a production volume of 160,100 tons (-13% compared to 2019), which accounts for 95% of the pome fruit harvest. Over three quarters of this was harvested in Styria (Statistik Austria, 2020a).

Apple producing regions in Austria

Most of the apple orchards in Austria are located in Styria with a cultivation area of 4,900 ha, which corresponds to 76% of Austria’s apple area (Figure 4). The apple acreage decreased by 5% from 2012 to 2017 and a further decrease is visible in the comparison of the yield report 2020 and the census in 2017. In the growing region Lower Austria, the apple area amounts to 600 ha. The regions Burgenland and Upper Austria have a comparable production area with 337 and 358 ha respectively, but 2020 the difference in yield per ha was considerable (Statistik Austria, 2020b).

Farms in Austria are in general rather small; more than half of the farms have 2 ha or less of cultivation area. In Styria, as main apple production region, the share of larger farms is higher than in all other regions. Farms with sizes from 10–20 ha and above 20 ha are seldom; for Austria, the category of 10–20 ha comprises 1,991 ha and 140 farms, respectively.

Although the number of very small apple farms is high, their share of apple acreage is only 8% of Austrian apple orchards (Figure 5). About 40% of the cultivated apple area in Austria – and Styria as main growing region of apple – is managed by farms with 5–10 ha of cultivation area. Burgenland has a comparatively high share of few, large farms, which corresponds to a cultivation area of 226 ha, or 56% of apple area of the region. The high number of small and very small farms shows a relevance regarding the cultivation area in Lower Austria. Regarding the typical farms, the size categories 5–10 ha and 10–20 ha are, considering the cultivation area, the most important farm structure in Austria, but small farms are typical in Austria, too (Figure 5).

Important apple varieties and marketing channels

The most important varieties in Austria are ‘Gala’ with a share of 24% of the cultivated area, ‘Golden Delicious’ with

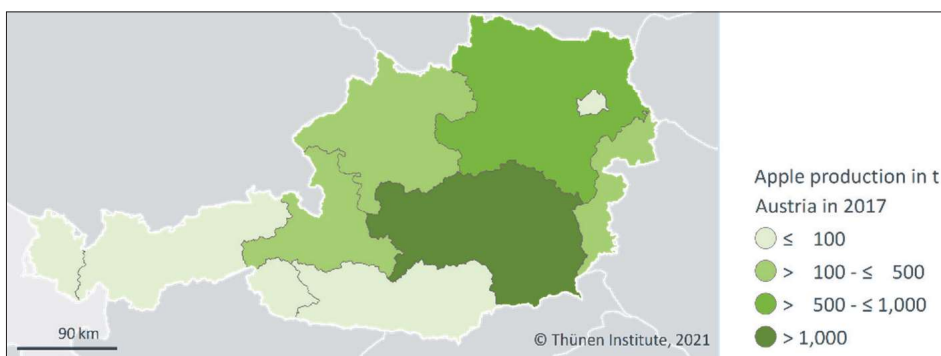


FIGURE 4. Apple production in Austrian federal states in 2017 (map). Source: Statistik Austria (2018), © Euro Geographics (2018).

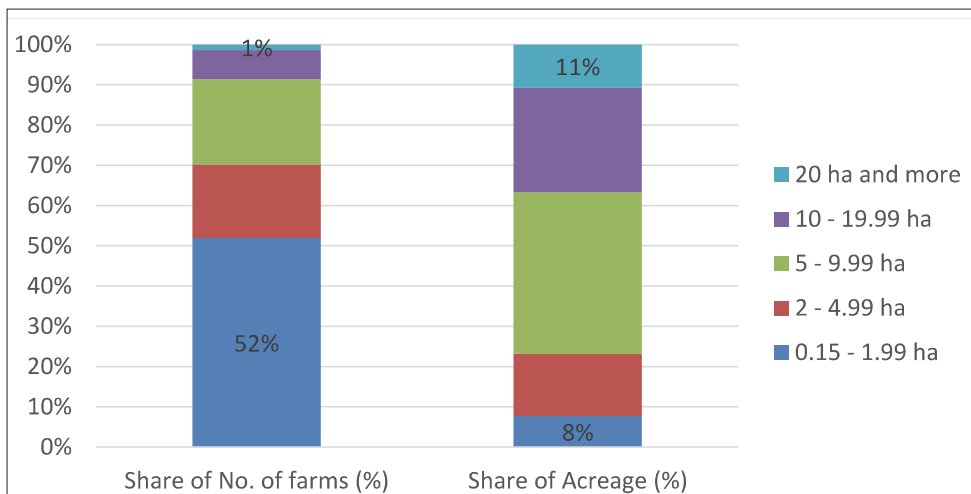


FIGURE 5. Percentage share of number of farms and of apple acreage according to size categories of apple cultivation area 2017. Source: Statistik Austria (2018).

22%, ‘Jonagold’ with 9%, ‘Idared’ 7% and ‘Braeburn’ 7%. The cultivated area of the ‘Topaz’ varieties was further expanded with 470 ha (6% area share), ‘Elstar’ (5%), ‘Pinova’ (4%) and ‘Kronprinz Rudolf’ (2%), while ‘Arlet’ (2%) decreased. The ‘Gala’ variety dominates organic fruit growing with an area share of 23%, followed by ‘Topaz’ with 21% and ‘Golden Delicious’ with 13% (Statistik Austria, 2018).

In Austria, with regard to the marketing channels for all fruit categories, the producer organizations are of the greatest importance as buyers (yield of 39% of the area). In second place, with a share of 29%, are retailers as a marketing channel, followed by direct marketing with 22%, while 10% of the cultivated area is intended for processing. In the case of pome fruit, the yield of 52% of the production area was marketed through a producer organization, 26% went to retailers.

Apple trade in Austria

About 115,000 tons of apples were imported, whereas about 68,000 tons were exported at an average of the years 2016 to 2018. Italy, Czechia, Germany and Hungary were the four most important apple supplier countries, followed by Croatia, Slovenia, Ukraine and Poland. Further apple-producing countries in Europe and overseas play a subordinated role (UN Comtrade, 2021)

Regarding export, Germany represented on an average of 2016–2018 the most important market with 23,000 tons according to UN Comtrade (2021).

CZECHIA

Statistical overview

Apples trees are dominant in Czech production orchards and are the most important fruit trees in Czechia. According to Buchtová (2019), in 2019 apple trees in production orchards covered 6,828 ha, that is nearly half of the total area of production orchards.

The statistics around apple production in the last 10 years (2009–2019) show that the area allocated for apple production has decreased by 25% (from 9,135 hectares in 2011 to 6,828 ha in 2019). Since 2015, there have been significant reductions in the area of production orchards (Figure 6). There are several causes of this decrease, from setting up new grants conditions and tightening of the definition of “orchard” culture in the land register, to disposal of old orchards without replacement. The reason for orchard disposal of orchards is the poor economic situation of Czech fruit growing in recent years, when the profitability of fruit growing is declining more and more. Concurrently, the apple production quantity varies greatly from year to year. In this time period the largest production was above 155,000 tons in 2015, while the fewest apples were produced in 2011, just about 79,000 tons. The yield is affected by annual weather conditions like late spring frosts (in 2016, 2017 and 2019) and drought (in 2015 and 2018).

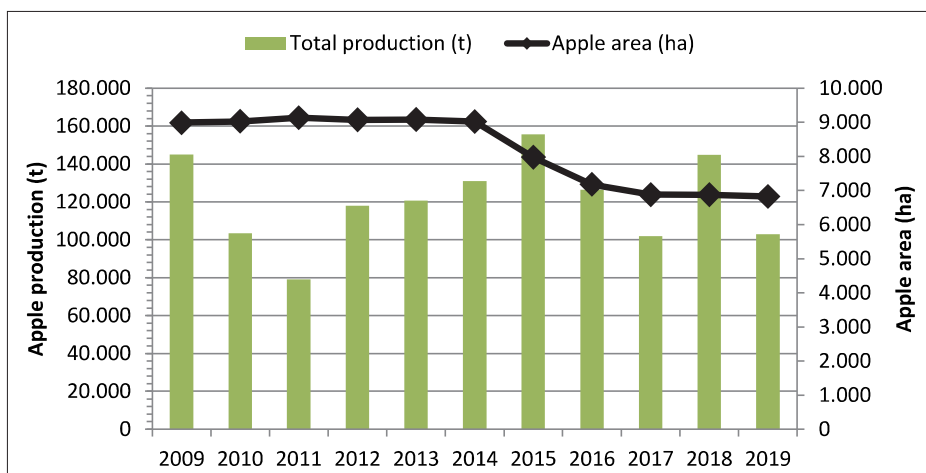


FIGURE 6. Total apple production and area in production orchards between 2009 and 2019 in Czechia. Source: Buchtová (2020).

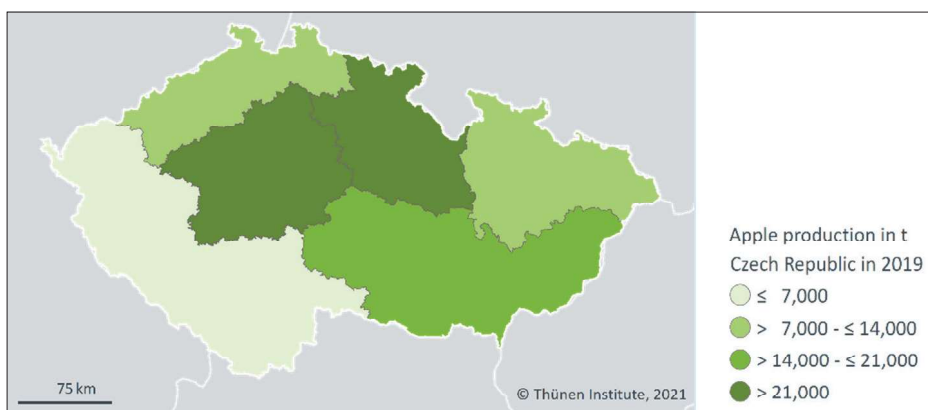


FIGURE 7. Apple production in Czech regions in 2019 (map). Source: Buchtová (2020), ©EuroGeographics (2018).

Apple producing regions in Czechia

In Czechia apples are produced more or less all over the country, so it is hard to identify the main apple producing regions. According to statistics, apple production is highest in the Central Bohemia region, and second-highest in the East Bohemia region. In three other regions – South Moravia, North Bohemia and North Moravia – production is more less equal (Figure 7). The smallest production comes from the South and West Bohemia region. In 2019 the Central Bohemia region had a 31.9% share of the total apple production in Czechia and 24.9% of total production area; the East Bohemia region produced 23.6% of the total production and covered 17.2% of the total area. Together these two regions covered over 50% of total production on 42.1% of the total production area in Czechia.

Important apple varieties and marketing channels

The total amount of harvested apples from production orchards in 2019 was 102,847 tons. About 62,000 tons (60.3%) were used as table fruits, 35,000 tons (34.0%) were used for industrial purposes, and 5,847 tons (5.7%) were not marketed (Fruit Union of Czech Republic). The proportion of apples intended for industrial purposes in the last decade ranges from 34% in 2019 to 55% in 2015.

According to Buchtová (2020), ‘Golden Delicious’, ‘Idared’ and ‘Jonagold’ are the three most important apple varieties in Czechia based on the area of production in 2019. Further important apple varieties in Czechia are ‘Gala’, ‘Rubín’ and ‘Bohemia’, ‘Champion’, ‘Spartan’ and ‘McIntosh’, ‘Topaz’ and ‘Rubinola’.

Apple trade in Czechia

On average, almost 70,000 tons of apples are imported

to Czechia annually. In the case of table apples, that represents around half of demand. According to Buchtová (2020), Poland, Italy and Slovakia have been the three most important apple supplier countries for Czechia between the years 2016–2018. The most dominant supplier country is Poland, with around 38,000 tons per year.

GERMANY

Statistical overview

Apple trees play a major role in German fruit production and are the most important fruit trees in Germany. According to the German fruit tree census apple trees covered an area of around 34,000 ha in 2017, this were around 44% of the fruit production area and 68% of the fruit tree production area (Destatis, 2017).

The apple production statistics of the last 10 years (2009–2019) shows an apple production area with values ranging between around 31,000 ha (2016) and 34,000 ha (2019) (Figure 8). While remaining almost on a stable level with a slight decrease between 2009 and 2016, the apple area in Germany apparently increased significantly between the year 2016 and 2017. Certainly, this phenomenon rather needs to be traced back to the fact that one main producing region changed its data collection procedure (Garming et al., 2018). Furthermore, the production quantity of apples largely varies between the years. In this time period the largest production quantities were around 1.20 million tons in 2018, while in 2017 were least apples produced, namely around 0.60 million tons (Figure 8). These large variances are caused on the one hand by alternation of apple trees and on the other hand by extreme weather events like spring frost, hail, and variable rainfalls (Garming et al., 2018).

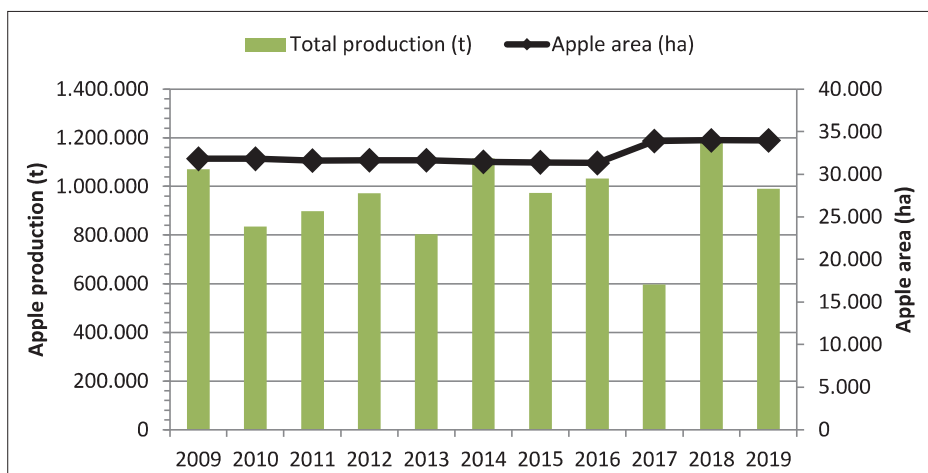


FIGURE 8. Total apple production quantity and area between 2009 and 2019 in Germany. Source: Destatis (2020).

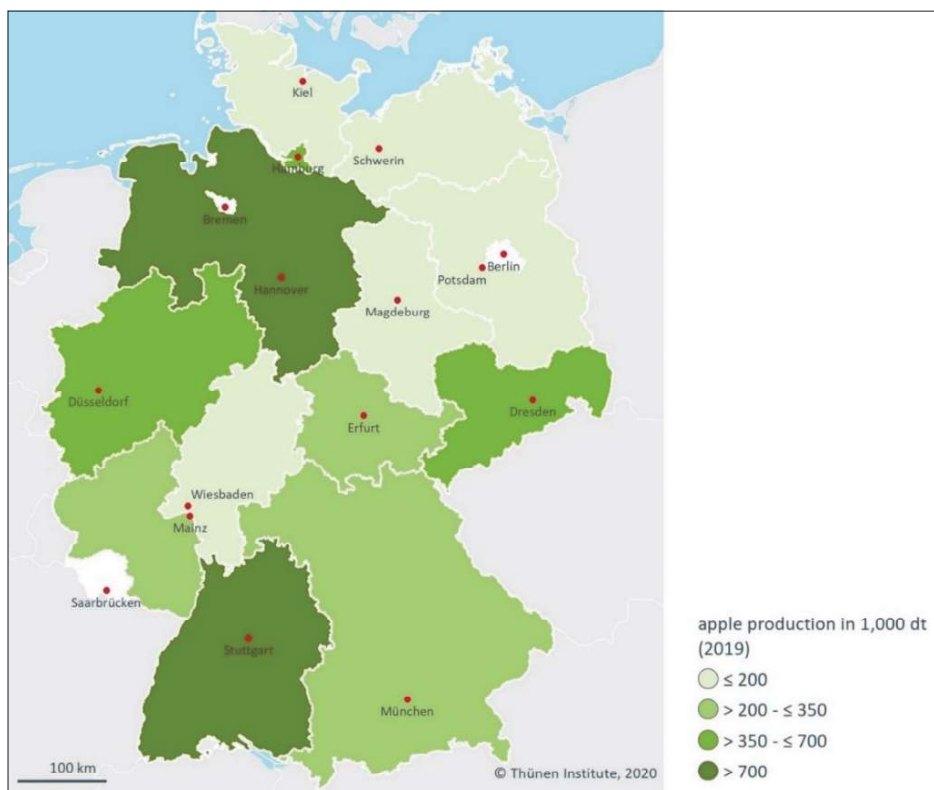


FIGURE 9. Apple production in German federal states in 2019. Source: Destatis (2020), ©GeoBasis-DE/BKG (2019).

Apple producing regions in Germany

Germany has three main apple producing regions, namely Altes Land (located in the countries Hamburg and Lower Saxony) in North-West Germany, Saxony (located in the country Saxony) in the East of Germany and Lake Constance (located in Baden-Württemberg) in the South. In 2019 Altes Land had a share of 32.1% of total apple production in Germany and 27.9% of total production area; Saxony produced 6.6% of total production and covered 7.0% of total apple production area in Germany and Lake Constance had a total production share of 40.2% and a share of 35.6% of the total area (Garming et al., 2018). So, the three most important fruit producing regions in Germany produced 79% of German apples on 71% of Germany's apple production area (Garming et al., 2018). Figure 9 shows the location of the three most important producing regions in Germany.

Farm sizes largely vary between the different production regions in Germany, which is partly caused by historical circumstances. Farms in the South of Germany are traditionally smaller, while farms in the North and in the East of Germany are significantly larger (Garming et al., 2018). Due to the formerly existing large cooperative structure in the East of Germany particularly Saxony has large farm sizes. Figure 10 provides an overview of the percentage share of the number of apple producing farms according to the size categories of cultivation area. In the region Altes Land and Saxony there are more apple farms with larger area sizes; most farms there have 20 ha and more. In contrast, Baden-Württemberg has mainly small farms; most farms there have between 0.5 and 2 ha. Due to the smaller average farm size in Baden-Württemberg the country has a much higher number of farms than Saxony, Hamburg and Lower Saxony.

Important apple varieties and marketing channels

Out of the 991,451 tons of apples that were harvested in 2019, around 708,198 tons (71.4%) were used as table fruits,

271,228 tons (27.4%) for industry purposes and 12,026 tons (1.2%) were not marketed (Destatis, 2020). Depending on harvest quantity and quality between 23 and 30% of the apple harvest is normally used for industry purposes (Garming et al., 2018).

According to the 2019 apple production statistic 'Elstar', 'Gala' and 'Braeburn' are the three most important apple varieties in Germany based on the area of production, with 18%, 7% and 6% of total area. The regional distribution of varieties depends on climatic conditions. 'Elstar' plays a major role in the region Altes Land that means in the countries Hamburg and Lower Saxony and has a share of 33% respectively 32% of the production area there. 'Gala' is typically cultivated in Saxony and Baden-Württemberg, but only with a minor share in the North. 'Pinova', 'Idared' and 'Golden Delicious' are almost only found in Saxony, while 'Holsteiner Cox' is only grown in Altes Land.

Apple trade in Germany

Apple imports cover with a quantity between 600,000 and 700,000 tons per annum between 35 and 45% of the domestic demand. Therewith, apples are the second important imported fruit in Germany (Garming et al., 2018). According to UN Comtrade (2021) Italy, Poland, the Netherlands, France and New Zealand have been the five most important apple supplier countries for Germany between the years 2016–2018. Italy is the most important supplier of apples to Germany with around 241,000 tons per year (UN Comtrade, 2021).

Several major supplier countries are German neighbor countries with similar climate conditions and harvest seasons. Imports from the Southern hemisphere became less important during the last years as apples have a great storage suitability and the storage technologies in Germany continuously improve. Thus, this enables an all-season supply with European fresh apples (Garming et al., 2018).

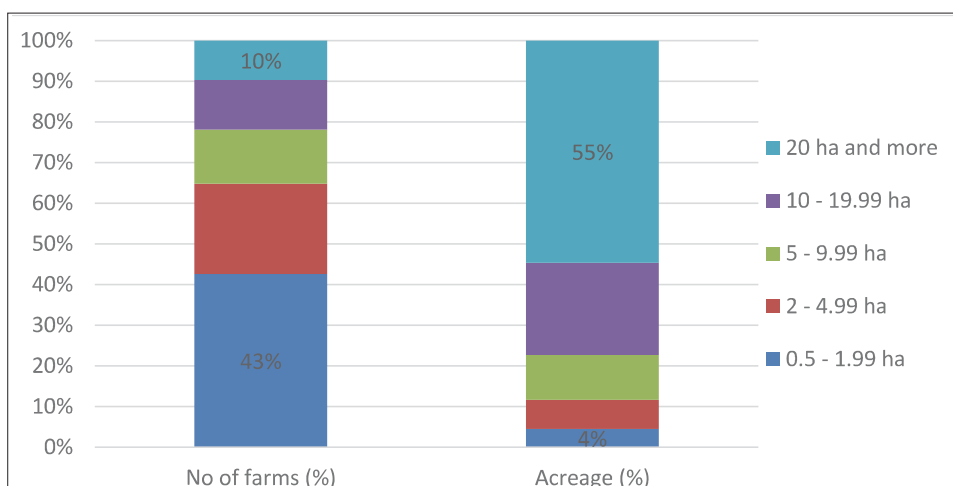


FIGURE 10. Share of number of farms and apple acreage according to size of apple cultivation area in Germany, 2017. Source: Destatis (2017).

HUNGARY

Statistical overview

The Hungarian fruit sector is dominated by apples, as according to the Hungarian Central Statistical Office (Központi Statisztikai Hivatal, 2020a), about 37% (30,974 ha) of the fruit production area was covered by apple trees in 2019. The production area of apples in Hungary has fallen by about 15% for the last years: from 36,644 ha in 2009 to 30,970 ha in 2019, while production volume was highly volatile, reaching its low in 2011 with 293,000 tons and peaking in 2014 with 778,000 tons. The production volume in 2019 fell below the 2009–2019 average, owing to weather extremes and the alternation after exceptionally rich harvest in 2018, as shown in Figure 11. The high share of ageing orchards (in 2017, apple orchards older than 20 years represented 21% (Központi Statisztikai Hivatal, 2017)), orchards exposed to frost and hail damage or water stress (irrigated apple orchards covered 21% in 2017 (Központi Statisztikai Hivatal, 2017)) as well as orchards in medium to poor condition (38% of orchards (Központi Statisztikai Hivatal, 2017)) could also lead to yield fluctuation. With 498,000 tons, Hungary ranked eighth among the apple grower countries in the European Union and accounted for 6% of the total EU apple production in 2019, however, the average yield of 15.6 tons ha⁻¹ in 2019 was significantly lower than the EU average.

Typically, two thirds of the Hungarian apple crop go to industrial processing and one third to direct consumption, however, apple for processing can be sold at significantly

lower price than apple for fresh market. In 2019, apple orchards were hit by weather extremes (late-onset frost, hail, summer and autumn drought), which further increased the percentage share of apples used for industrial processing (FruitVeB, 2020). Lower processing prices reduce the income of apple producers; this is why the apple area steadily decreased between 2009 and 2019.

Apple producing regions in Hungary

Szabolcs-Szatmár-Bereg county (located in North-East Hungary) is the leading producer of apples in Hungary, with a share of 59% of the total apple yield in 2019, followed by Borsod-Abaúj-Zemplén (located in North-East Hungary) and Hajdú-Bihar (located in North-East Hungary) counties with 7% respectively (Figure 12). The share of other counties in production volume ranged from 1 to 5% in 2019. According to the Hungarian fruit tree census (Központi Statisztikai Hivatal, 2017), in 2017, 70% of the apple growing area was in Szabolcs-Szatmár-Bereg county, while Bács-Kiskun and Borsod-Abaúj-Zemplén counties together accounted for 11% of the total apple production area.

Based on Hungarian Payment Agency (2021) data, 6,006 farms produced apples in 2019. Just over five years, the number those farms fell by 10.5%. Figure 13 shows, how the number of farms relates to the farm size. In Hungary, 47% of the apple producers were in the 1 to 5 ha apples orchard size category, and 92% of them had less than 10 ha covered by apple trees in 2019; however, farms in the 1 to 5 ha category accounted for 28% of the total apple area, while farms with less than 10 ha of apples used 55% of the total apple-

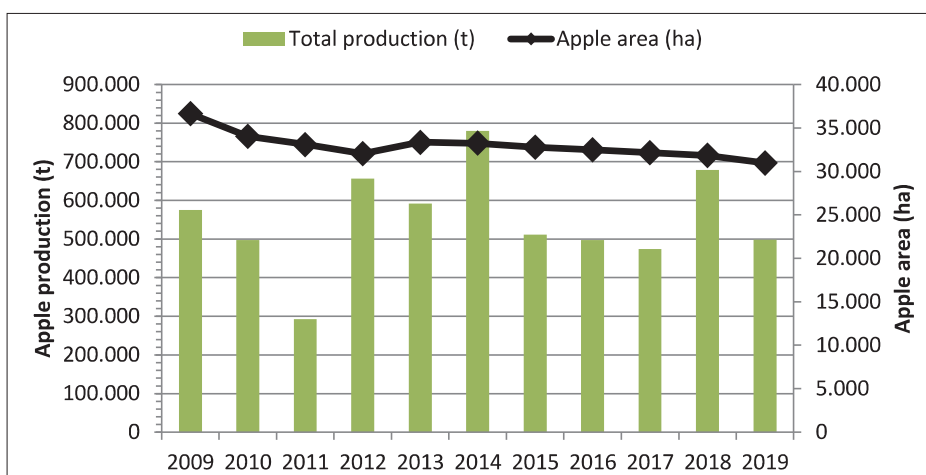


FIGURE 11. Total apple production quantity and area between 2009 and 2019 in Hungary. Source: Központi Statisztikai Hivatal (2020b).



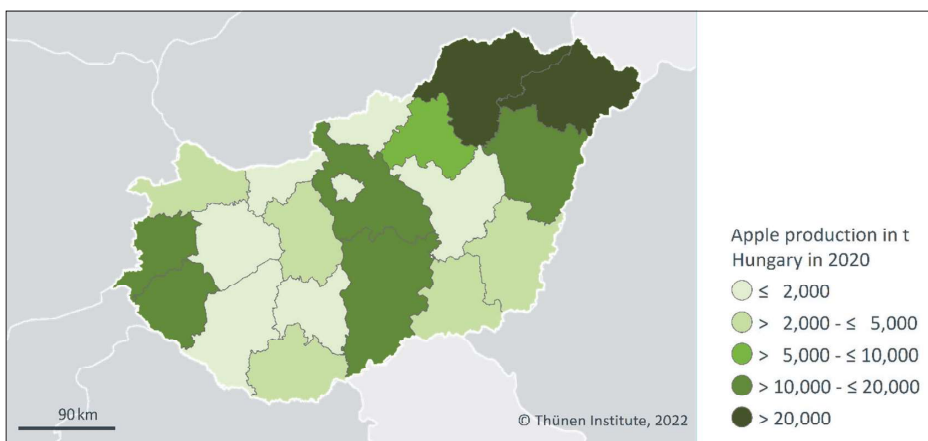


FIGURE 12. Main producing counties in Hungary and production quantity in tons. Source: Központi Statisztikai Hivatal (2020b), ©EuroGeographics (2018).

growing area. In contrast, farms with over 10 ha of apples cultivated 45% of the total apple-growing area.

Important apple varieties and marketing channels

According to the Hungarian fruit tree census (Központi Statisztikai Hivatal, 2017), ‘Idared’ was the most important apple variety in 2017 based on production area. Although ‘Idared’'s share of the apple production area in Hungary was 23% (22% in Szabolcs-Szatmár-Bereg, 23% in Borsod-Abaúj-Zemplén and 14% in Hajdú-Bihar county), as it is a well-storable variety, consumer tastes are shifting. ‘Florina’ (also known as ‘Querina’), ‘Jonagold’ and ‘Remo’ were grown on 6 and 5%, respectively, of the country’s apple-producing areas. In Szabolcs-Szatmár-Bereg county, ‘Remo’ ranked third, while in Hajdú-Bihar county, ‘Idared’ and ‘Golden Delicious’ Reinders were produced in the largest area, and in Borsod-Abaúj-Zemplén county the ranking was the same as at the national level. In 2017, further important apple varieties were ‘Golden Delicious B.’, ‘Jonathan M 40’, ‘Gala’, and ‘Relinda’. The share of other varieties grown in smaller areas exceeded 40% nationwide.

Organic apple production is still marginal in Hungary, though the controlled area increased remarkably between 2009 and 2019 from 592 ha to 4,149 ha. Organic apple cultivation was carried out only in 373 ha in 2009, but it increased to 2,166 ha by 2019. Since 2016, the increase in organic apple area has been accelerating, as the area in conversion in 2016 to 2018 was even larger than total organic apple area. In 2019, the area in conversion is 1,960 ha, which is slightly less than the accredited organic apple area. Not only the area

but also the share of apple orchards within the total organic increased between 2009 and 2019, from 0.4 to 1.5% (Roszák, 2021; Bio Garancia, 2021).

Apple trade in Hungary

According to UN Comtrade (UN Comtrade, 2020) fresh apple imports in 2019 were the third highest in quantity in the last decade, and the volume of imports fluctuated between 85,008 tons in 2011 and 8,863 tons in 2009. In 2019, 30% of the imported fresh apples came from the EU, while Serbia was the main supplier with an exceptionally high 25,552 tons and 60% share in the quantity of apple imports. Over 2016–2019 the major suppliers were European countries: Serbia, Poland, Romania, Germany and Croatia. Export volumes fluctuated over 2009–2019, resulting in 16,545 tons in 2016 and 41,749 tons in 2013. In 2019 the main export market for Hungarian apples was Austria (one-third in volume), followed by Slovakia and Germany.

ITALY

Statistical overview

Apples are the first fruit and vegetable product in Italy by quantity and plays a key role both on the domestic market, with consumption made lively by the introduction of new patented varieties, and on the global market, being one of the most exported fruits. Italy is the second largest producer country in Europe, just behind Poland. Considering all tree fruit cultivations (including citrus fruits and nuts), apple ranks first in terms of production, holding a 27% share.

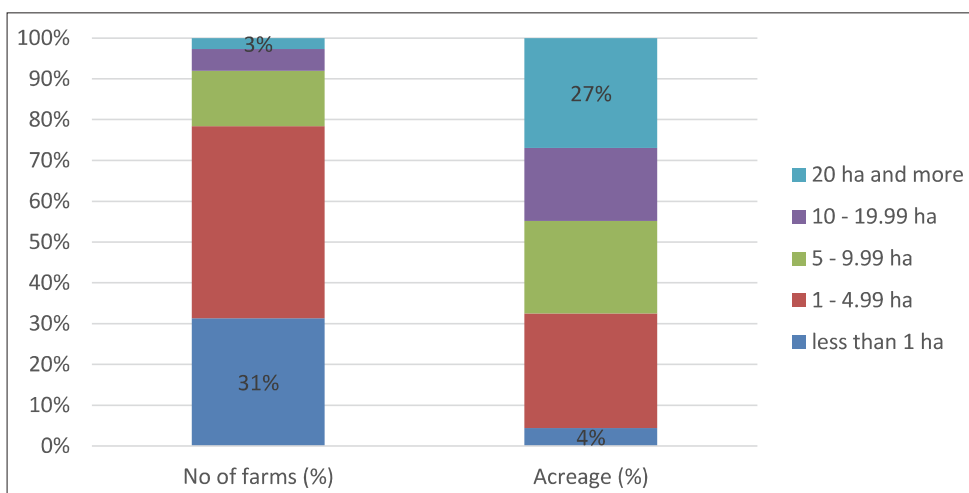


FIGURE 13. Percentage share of number of farms and apple acreage according to size categories of cultivation area, 2019. Source: Hungarian Payment Agency (2021).

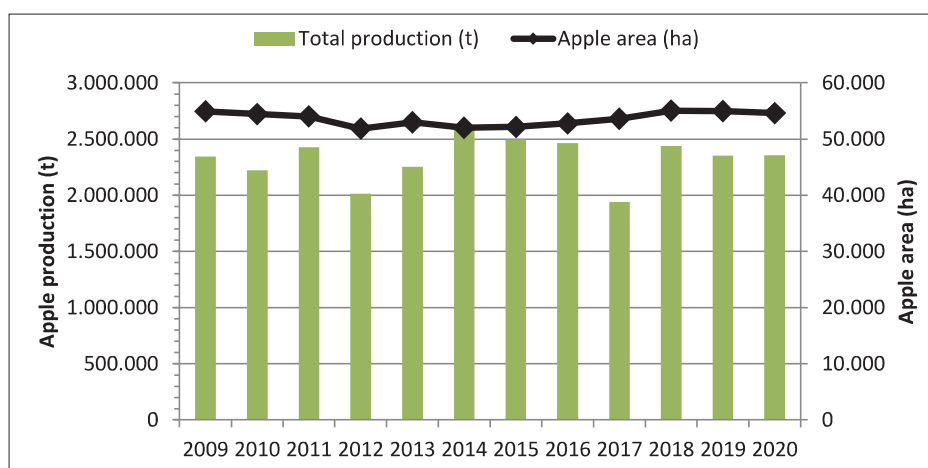


FIGURE 14. Total apple production quantity and area between 2009 and 2020 in Italy. Source: ISTAT (2021).

In the last 10 years, according to ISTAT data, the total area invested in apple trees in Italy has remained stable (-2%), going from just under 58,500 ha in 2009 to the current 57,200 ha in 2020, recording a more pronounced decline in 2012 and 2014, when the value fell below fifty-five thousand ha (Figure 14). On the contrary, the total production, which stood at 2.3 million tons in 2020, shows a more fluctuating trend, due partially to the alternation that characterizes the species, but mainly to the anomalous climate that characterized 2012 and 2017 campaigns (2 and 1.9 million tons respectively), when late frosts led to an excessive sagging with consequent crop loss (Figure 14).

In the same period, the cultivation of organic apples showed a marked increase. In particular, the areas were equal in 2009 to 3,346 ha and continued to fluctuate, depending on the years, between 3,500 and 4,000 ha until 2015. Subsequently, the strong demand on the market and the refinement of techniques for the containment of plant diseases boosted the adoption of organic production methods, so that the areas have gradually increased, reaching 8,235 ha in 2019 (14% of the cultivated area).

Apple producing regions in Italy

The Italian apple production is highly concentrated. Just under 90% of it comes from four regions in the north of the country: Trentino-Alto Adige, Veneto, Piedmont, and Emilia-Romagna. According to ISTAT data, in 2020 Trentino-Alto Adige accounted for 60.8% of national apple production obtained on an area equal to 49.5% of the total area planted with apple trees, Veneto for 13.4% and 10.8% respectively, Piedmont for 7.6% and 11.3% and Emilia-Romagna for 6.4% and 8.3% (Figure 15).

Unfortunately, data relating to apple cultivation distinguished according to farm size, are available only based on an ISTAT survey dated 2010. Considering the 50,625 farms that grew apples in Italy, 42.6% were less than 2 ha, 27% between 2 and 5 ha, 15.5% between 5 and 10, 8.7% between 10 and 20, and just 6% over 20 ha. If we analyse the same data in the most important production area, i.e., in Trentino-Alto Adige, there is a higher figure in the share of farms with less than 2 ha (48.4%) and between the 2 and 5 ha (33.2%). This region is characterized indeed by small hilly farms, which often practice monoculture. This specialization, together with the suitability of the territory, explains the high unit yields. In Veneto and Piedmont, on the other hand, the share of smaller farms (<2 ha) decreases compared to the national figure (respectively 24% and 30.7%), and that of medium-large farms increases.

Important apple varieties and marketing channels

Apple production in Italy is predominantly oriented to the table fruits market, while, due to the lack of a significant local demand, apple juices, apple sauces or dried apples are still relegated in market niches. This orientation of the industry, combined with favourable environmental conditions, led to the registration under the EU procedure of five Protected Geographical Indications (PGI) and one Protected Designation of Origin (PDO) concerning fresh apples. Two PGI's (Mela Alto Adige/Südtiroler Apfel and Mele del Trentino) and the one PDO (Mela Val di Non) are located in the Trentino-Alto Adige region, whereas the remaining three PGI's areas are respectively located in Piedmont (Mela Rossa Cuneo), Lombardy (Mela di Valtellina) and Campania (Melannurca Campana) regions.

According to the most recent data by Assomela (2020), the Italian association of apple producers 'Golden Delicious' is the most important, although slightly declining, apple variety in Italy, with 38% of the production quantity. Further important apple varieties in Italy are 'Gala' (16%), 'Red Delicious' (11%), 'Granny Smith' (7.5%) and the late ripening 'Fuji' (8%) and 'Cripps Pink' (5%). Apart from that, data also show increasing production trends for the so called "new varieties" ('Kanzi', 'Jazz', 'Ariane', 'Belgica', 'Cameo', 'Diwa', 'Greenstar', 'Honey Crunch', 'Jazz', 'Junami', 'Mariac', 'Rubens', 'Tentation', and 'Wellant').

Apple trade in Italy

Apples are the fruit with the highest net balance for Italy. In fact, with the exception of 2018 when the crop losses endured in the previous harvest did impact on both exports and imports, in the recent years Italy's apple exports amount to about 1 million tons, whereas imports did not exceed 56,000 tons. According to UN Comtrade (2021) the most important purchaser country for Italian apples is by far Germany, which demands between 24% and 32% of all exports. Other relevant export markets are those of traditional major Italy's trade partners: Spain, France, United Kingdom, Austria, and the Netherlands purchase, as a whole, slightly over than 20% of the total exports. A second critical group of purchaser countries, with a share of just under 20%, is located in the Middle East: Egypt, Saudi Arabia, Jordan and United Arab Emirates. A third group is composed by Nordic countries like Sweden, Norway and Denmark, whose purchase amount to about 10% of total exports. A peculiar case is represented by India in 2019 – its main supplier, China, had production losses and there was a boom in Italian exports (6% both in quantity and in value) which halved the following year.

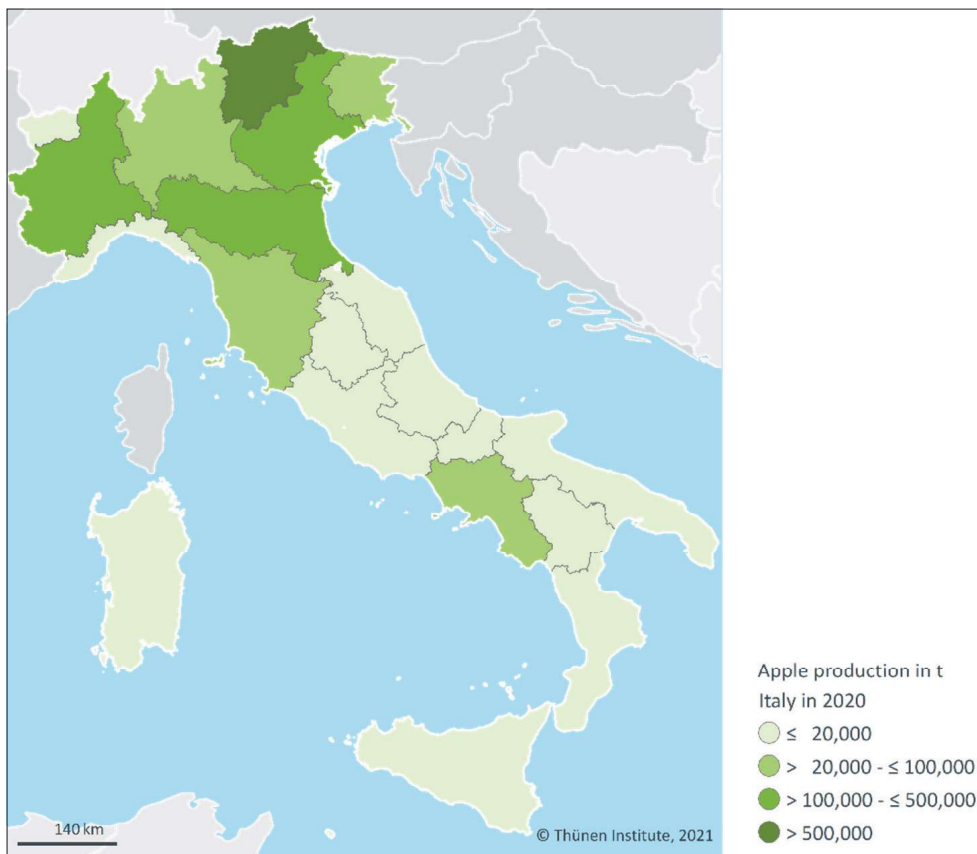


FIGURE 15. Apple production in Italian regions (map). Source: ISTAT (2021), ©EuroGeographics (2018).

Concerning the apple imports, the UN Comtrade (2021) data show that the five most important apple supplier country for Italy have been France, Poland, Hungary, Austria and Germany. Even if part of the imports from Germany likely regarded apples harvested in the Southern Hemisphere, these data show that the development of storage technologies affected the international apples trade flows.

POLAND

Statistical overview

For several years, Poland, with the production of apples over 3 million tons, has been in the first place in Europe and third in the world, after China and the U.S.A. According to the latest estimates, the harvest of apples in 2020 will significantly exceed the level of 3.4 million tons, and in the near future, assuming no unfavorable weather conditions, Polish apples production may exceed the level of 4 million tons.

Thanks to investments made by fruit growers in new varieties and improvement of apple quality, Poland has a chance to use emerging export opportunities to previously unattainable destinations. Compared to other EU countries, Poland has advantages in the use of production factors, i.e., land and labor; Poland has improved the use of the capital factor, the lack of which was the cause of the technical weakness of Poland's agriculture, including fruit growing. Poland's membership in the EU contributed to this, and earlier aid funds from agricultural development programs. Poland, compared to other European countries, is definitely distinguished by a very large number of fruit farms in the production of apples. Their number in all European countries, except Poland, is decreasing. In most commercial farms, apple production is carried out on the area of 5 to 20 ha (Figure 16), and the yields range from 22 to over 60 t ha⁻¹. In Poland, there are still a lot of low-commodity farms producing apples, mainly used for the production of apple concentrate. As a result of accession

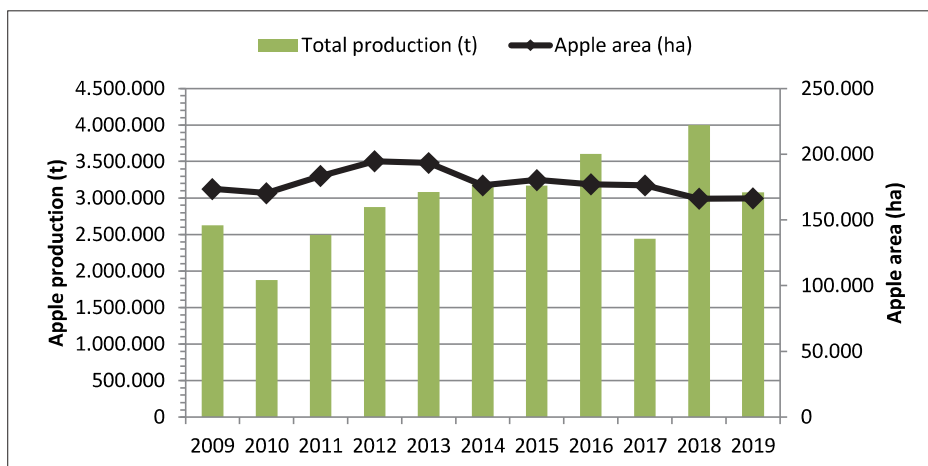


FIGURE 16. Total apple production quantity and area between 2009 and 2019 in Poland.

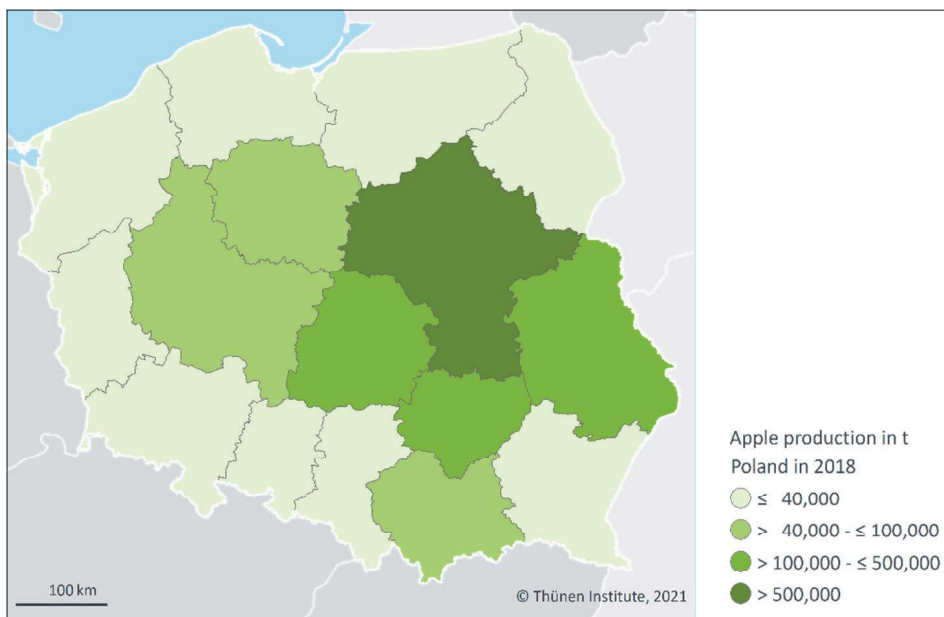


FIGURE 17. Apple production in Poland in 2019 by voivodeship (map). Source: GUS (2019), ©EuroGeographics (2018).

to the EU, the Polish fruit-growing industry is constantly modernizing. Numerous producer groups were established and quality standards and safety systems were implemented in apple production, both at the farm and GP level. These changes resulted in a very large increase in the quality of the fruit and enable the sale of Polish apples on the global market.

In 2017, a representative orchard survey was carried out in Poland, the purpose of which was to obtain detailed data on apple cultivation. This regular survey is carried out every five years in accordance with the current requirements of the European Union.

Results showed that among the people managing fruit production, middle-aged people prevailed, i.e., between 30 and 59 years of age (74.4%), at the same time the share of younger people decreased, and the share of older people definitely increased among people managing fruit production, approx. 22.5% had education in horticulture (at various levels), of which nearly one third had secondary education in horticulture. Compared to the results of the 2012 survey, the share of people with higher education in horticulture has increased; horticulture in Poland continues to develop, more and more expenditure is allocated to fruit production and storage. However, this difference is lately fast decreasing due to the high increase of labor costs.

Apple producing regions in Poland

The production of apples in Poland is located mainly in the Mazowieckie Voivodeship. With about 73,000 ha of production area, this voivodeship covers 41% of Polish apple area. Mazovia is the third largest area concentrating apple production, after China and Washington State in the U.S. Other important apple regions are the voivodeships of Świętokrzyskie and Lubelskie with nearly 23,000 ha of production area each or about 13% of Polish apple area (Figures 17, 18).

From year to year, there is an increasing concentration and specialization of fruit production; the production potential of orchards, especially apple trees, is increasing. The generalized results of a representative survey of orchards showed that the cultivation of apple trees is constantly changing. A comparison of the results of the orchard survey in 2012 and in 2017 shows significant differences in the age structure of trees and the density of plantings in apple plantations. Over the five years since the previous study, a clear decrease in the share of the area of 15-year-old and older plantations and an increase in the acreage of apple orchards at the age of 5–14 years has been noted. However, the acreage of young orchards in establishment remained stable, indicating a stable rate of orchard renewal. A significant share

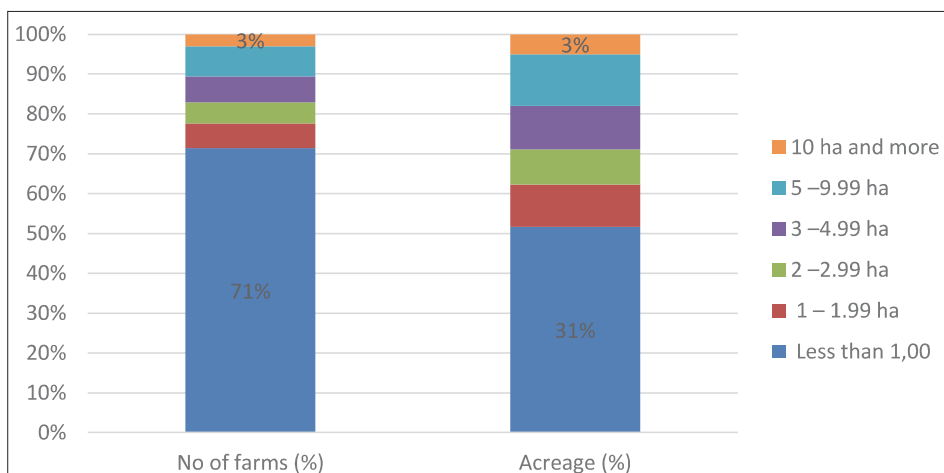


FIGURE 18. Number of farms and total fruit growing area in 2010, structured by farm size in Poland. Source: GUS (2019).

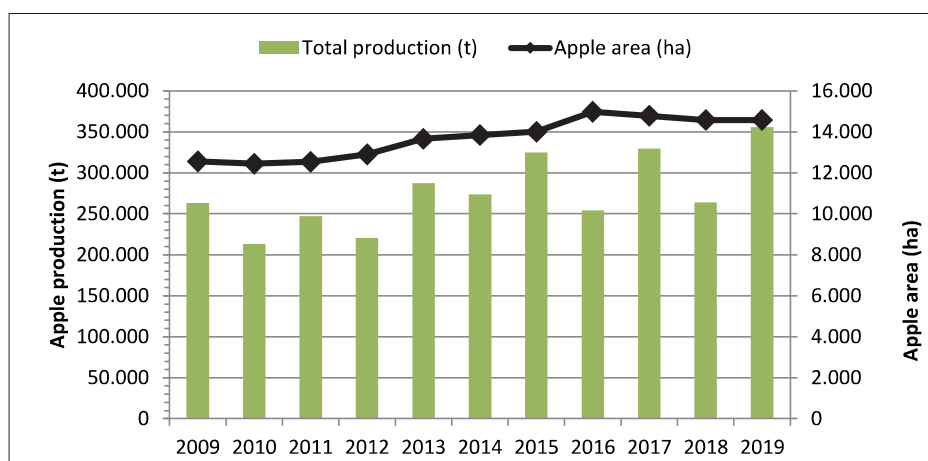


FIGURE 19. Total apple production quantity and area between 2009 and 2019 in Portugal. Source: INE (2020).

of young trees (up to 4 years old) was found for the 'Gala' variety (31.4% of the total cultivation area of this variety). A very large proportion of young orchards was also recorded for the 'Jonagold' group. In the case of the structure of planting density in apple tree plantations, during a five years period, the share of apple orchards with a density of more than 1,600 trees ha⁻¹ has nearly doubled and has reached 47% already, while a clear decrease in share of orchards with a lower density is observed. In 2017 only about 6% of apple area was planted with a density of up to 400 trees ha⁻¹, as compared to 18% in the previous census (GUS, 2019).

Important varieties and marketing channels

The varietal structure of the apple tree cultivation area in orchards is similar to that of the previous 2012 study. Comparing the results of the studies from 1998, 2004, 2007, 2012 and 2017, it can be observed that over the last 20 years some varieties have acquired high importance (including the 'Jonagold', 'Szampion', 'Ligol', 'Golden Delicious' and 'Gala' groups); others lose their importance and the area of their cultivation gradually decreases (e.g., 'Jonatan', 'Antonowka', 'Cortland' or 'Lobo'). Still the most common variety grown in Poland is 'Idared', whose share in the varietal structure remains more or less at the same level – over 20%. The cultivars from the 'Jonagold' group (including 'Jonagored' and other mutants) were second in terms of the size of the apple tree cultivation acreage in orchards in 2017 (17.5%), and their share in the varietal structure of apple orchards is constantly growing.

The results of the 2017 orchard survey showed that over 50% of the area of apple orchards in Poland was occupied by three groups of varieties: 'Idared', 'Jonagold' and 'Szampion'; among apple orchards more than half are plantations aged 5–14; in apple plantations there was a significant increase in the share of plantings in the planting of 1,600 trees and more per hectare; approximately 23.1% of the orchard area could be irrigated; among the possibilities of storing fruit, cold stores with a controlled atmosphere had the largest share (on average almost 38% of all stores and cold stores).

Apple trade in Poland

Poland is a major exporter of apples in Europe with an average of 903,000 tons of apple exports in the years 2016 to 2019 (UN Comtrade, 2021). Major destinations for Polish table apples were Belarus, Egypt, Kazakhstan, Romania and Germany. Also, Poland is an important supplier of apple juice concentrates, with average exports of 272,000 t in the years 2016 to 2019, of which 41% was supplied to Germany (UN Comtrade, 2021).

PORTUGAL

Statistical overview

Apple is the most important fruit crop in Portugal. According to the Portuguese National Institute of Statistics (INE) apple trees covered an area of around 14,577 ha in 2019, which represent 21.8% of the fresh fruits area – citrus crops together occupy 21,066 ha, 31.5% of the area (INE, 2021).

Over the last 10 years (2009–2019), the apple area evolved from 12,565 ha in 2009 to the actual 14,577 ha, with a peak in 2016 of 14,981 ha. The production varies a lot between years: during this 10-year period; 2019 was the best year, with a production of 355,697 tons, while the worst year was 2010, with 212,902 tons. Nevertheless, the worst year in what concerns productivity was 2016, with only 16,976 kg ha⁻¹, while in the best year, 2019, the productivity reached 24,401 kg ha⁻¹. The productivity varies a lot between years, namely because of the big differences in what concerns climatic conditions – temperature and precipitation –, sometimes extreme, like intense rainfall in the form of hail in early summer or heat waves in the summer. Figure 19 illustrates the apple production quantity and area between 2009 and 2019 in Portugal.

Apple producing regions in Portugal

The main production areas in Portugal are in the North and Center regions, which concentrate more than 90% of the total production area (Figure 20). In 2007, these two regions concentrated 96% of the area, respectively 1,755 ha and 4,277 ha, in farms of very small (under 4 European size unit (ESU)) and small (between 4 and 16 ESU) economic dimension.

In what concerns the physical dimension, both in the North and Center regions, farms less than 5 ha represent almost 21% of each of these regions. Nevertheless, the farms between 5 and 20 ha are the most common in the North (39.5%) and farms above 50 ha are most common in the Center (43.6%).

Important apple varieties and marketing channels

The most produced apple varieties in Portugal are some of the best known internationally, such as 'Golden Delicious', 'Royal Gala' (and others from the group 'Gala'), 'Red Delicious', 'Starking', 'Jonagold' and 'Jonagored', 'Reineta', but also some national varieties, such as 'Bravo de Esmolfe', 'Riscadinha de Palmela', 'Casa Nova' and 'Porta da Loja'. In Portugal there are 7 protected denominations for apples. Two of these are Protected Designations of Origin (PDO), 4 are Protected

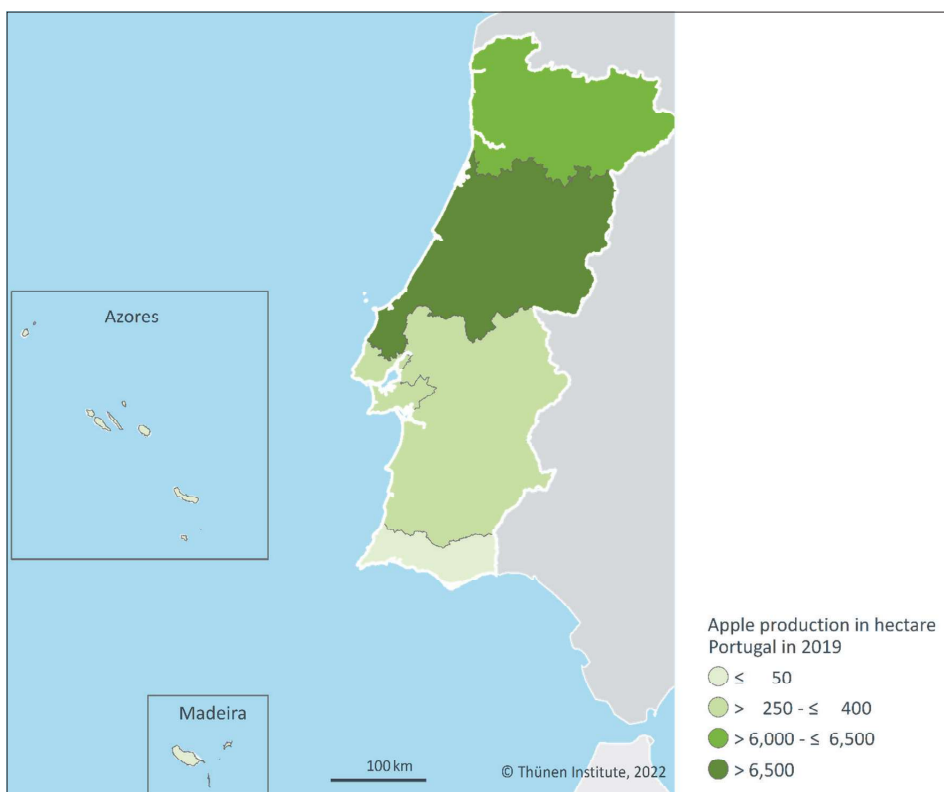


FIGURE 20. Main producing regions in Portugal. Source: GPP (2006), ©Euro-Geographics (2018).

Geographical Indication and one is protected as a Traditional Portuguese Product (DGADR, 2021). Some of these protected denominations are based on national and regional varieties. In addition to the aforementioned varieties, there are many other regional varieties with potential to serve as the basis for new protected denominations (DGADR, 2021; Ferreira et al., 2016; Mateus et al., 2020): ‘Apple Bravo de Esmolfe’ (PDO); ‘Apple of Beira Alta’ (PGI); ‘Apple of Cova da Beira’, (PGI); ‘Apple of Alcobaca’, (PGI); ‘Apple of Portalegre’, (PGI); ‘Apple Riscadinha de Palmela’, (PDO); ‘Apple Porta da Loja’ (Traditional Portuguese Product).

A total of 49,935 tons out of the 355,697 tons (14%) were produced under these denominations in 2019. This represented an area of 2,071 ha and a value of 42,862 thousand € (DGADR, 2021).

Apple trade in Portugal

The apple consumption in Portugal has been around 27 ± 3 kg per capita over the last 10 years, representing an average of 247,000 tons consumed per annum (INE, 2021).

Over the last 10 years, Portugal imported an average of 55,664.4 tons year⁻¹ of apples and exported 37,423.4 tons year⁻¹ (FAO, 2021). These exports, that represent 67.2% of the imports in number, represent however only 59% in value. According to FAO (2021), the most important apple suppliers, that covered ca. 90% of the imports over the last three years, were Spain (54%), France (38%), Brazil and Italy. At the same time, Spain also is the major destination for Portuguese apple exports; the quantities exported and imported are nearly equal. Some other countries also receive interesting quantities. Brazil is the second destination for Portuguese exports, followed by the U.K., France and the Netherlands.

SWITZERLAND

Statistical overview

According to the Swiss Federal Office for Agriculture (Bundesamt für Landwirtschaft, 2020), apples in high-density orchards were cultivated on an area of 3,736 ha in 2019. As the major fruit crop in Switzerland, apples accounted for

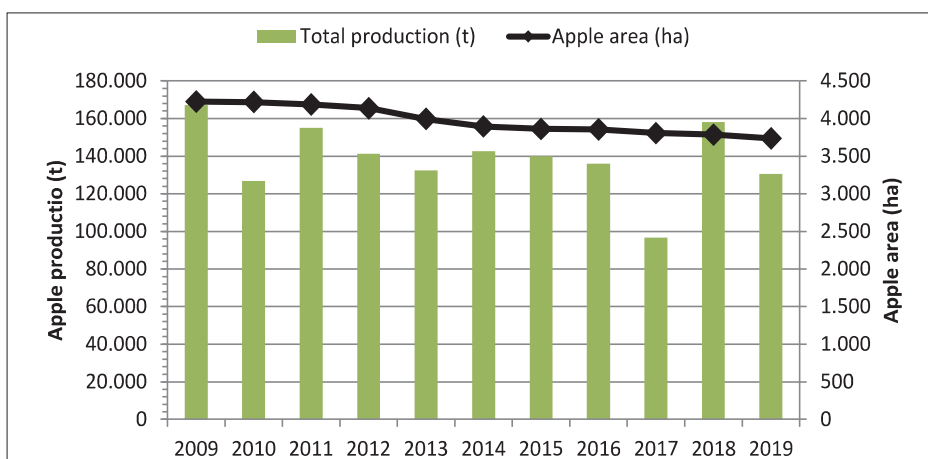


FIGURE 21. Total apple acreage and yield in Switzerland from 2009 to 2019. Source: Bundesamt für Landwirtschaft (2020) and Schweizer Obstverband (Schweizer Obstverband, 2019, 2020).

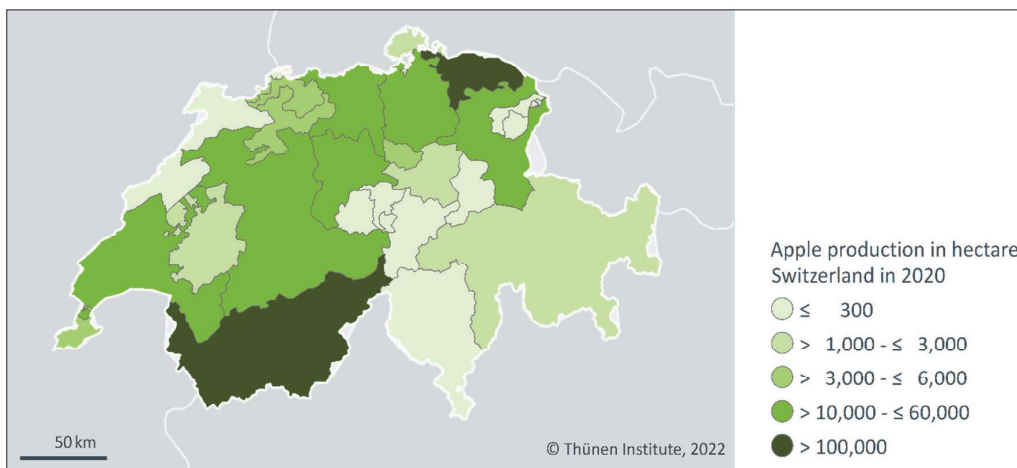


FIGURE 22. Apple acreage in Switzerland per canton, average 2009–2019. Source: Bundesamt für Landwirtschaft (2020), ©EuroGeographics (2018).

60% of all perennial fruit crops in 2019. Since the 1980s, the apple acreage in Switzerland decreases. From 2009 (4,226 ha) to 2019 (3,736 ha), it decreased by 12%. Due to weather and alternation of apple trees, the yearly yield varies. From 2009 to 2019, farmers obtained the highest yield in 2009 with 167,000 tons, whereas due to an early bloom and following harsh frosts, growers could only harvest around 96,500 tons in 2017. Figure 21 illustrates the apple acreage and yield between 2009 and 2019 in Switzerland.

Apple producing regions and farm structures

Although apples are cultivated all over Switzerland, three regions produce the most apples: Eastern Switzerland (cantons of Thurgau, St. Gallen and Graubünden), the canton of Valais and the Lake Geneva region (cantons of Geneva and Vaud) (Figure 22). On average between 2009 and 2019, farmers harvested 39% of the total Swiss apple yield in Eastern Switzerland, on 36% of the total acreage. The canton of Valais produced 27% of the total yield on 28% of the total acreage. The Lake Geneva region had a share of 18% of the total apple yield, produced on 16% of the total acreage. Growers produced the rest (16%) of the total yield on 19% of the total apple acreage, scattered in the remaining cantons of Switzerland (Bundesamt für Landwirtschaft, 2020; Schweizer Obstverband, 2019, 2020). Figure 22 shows the mean apple acreage of Swiss cantons from 2009 to 2019. The overall numbers of fruit growing farms in Switzerland is decreasing. In 1991, around 4,700 farms cultivated fruit on 7,050 ha (Bravin et al., 2011). Twenty years later in 2010, only 2,474 farms cultivated fruit on 6,624 ha. The number of farms that produce

fruit on 0.2 to 10 ha decreased during that time, whereas the number and total surface area of farms that cultivate more than 10 ha fruit increased. In 2010, only 5% of all fruit growing farms were larger than 10 ha, however they were cultivating together 37% of the total fruit growing area. Figure 23 shows the number of fruit farms and total fruit growing area in 2010, structured by farm size. Detailed data on apple producing farms is temporarily not available.

Important apple varieties and marketing channels

In 2019, the three most important apple varieties by acreage in Switzerland were ‘Gala’, ‘Golden Delicious’ and ‘Braeburn’ (Bundesamt für Landwirtschaft, 2020). The increase in acreage of red-skinned varieties such as ‘Gala’ and ‘Braeburn’ reflects the market trend in Switzerland (Bravin et al., 2011). ‘Golden Delicious’ was the most important variety by acreage from the beginning of the surveys in 1997 until 2007. In 2008, ‘Gala’ became the main variety by acreage grown in Switzerland. Since 2007, ‘Braeburn’ was the third most grown variety by acreage. ‘Jonagold’ and ‘Maigold’, two golden-skinned varieties, have lost importance since 2000. In recent years, club varieties such as ‘Scifresh’ (Jazz®), ‘Milwa’ (Diwa®, Junami®) or ‘Cripps Pink’ (Pink Lady®) gained more importance. While these club varieties accounted for 7.9% of the total apple acreage in 2009, the number rose to 18.6% in 2019.

‘Gala’, the most common variety in Switzerland, mainly increased its acreage over the last decade in the regions of Eastern Switzerland and the canton of Wallis. ‘Golden Delicious’ lost area in all growing regions equally. In 2019, the up-

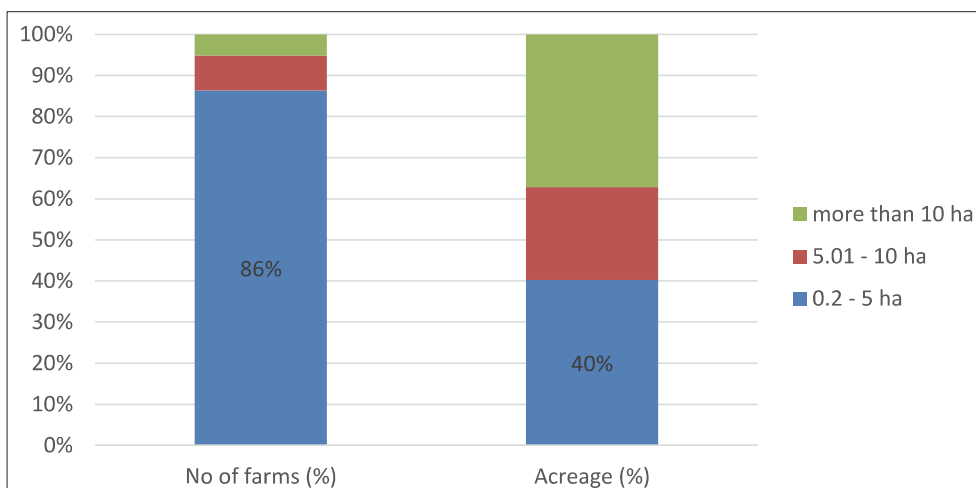


FIGURE 23. Number of farms and total fruit growing area in 2010, structured by farm size. Source: Bravin et al. (2011).

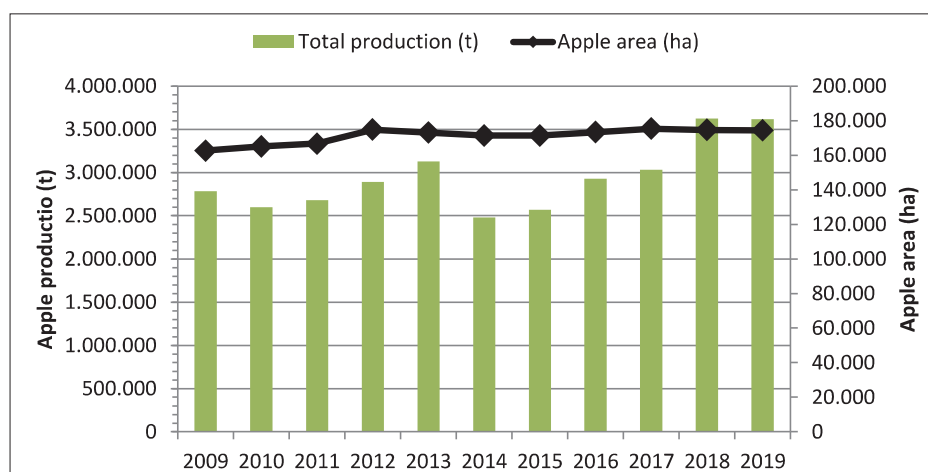


FIGURE 24. Total apple production quantity and area between 2009 and 2019 in Turkey. Source: TurkSTAT (2020).

coming club variety ‘Scifresh’ (Jazz®) was mostly cultivated in Western Switzerland (canton of Valais and Lake Geneva region), whereas the club variety ‘Milwa’ (Diwa®, Junami®) had larger shares in Eastern Switzerland and other regions.

Apple trade in Switzerland

The before mentioned statistics only include apples grown in orchards with a minimum of 300 trees ha⁻¹ (mostly around 2,000 trees ha⁻¹ in spindlebush-system). Additionally, standard apple trees (with a minimum trunk height of 1.6 m) growing on pasture are a common landscape element in Switzerland. In 2018, an estimated number of 1.2 million apple standard trees existed in Switzerland (Hochstamm Suisse, 2021). The Swiss fruit growers’ association estimated the total yield of apples in 2019 to be around 190,500 tons, consisting of approximately 136,500 tons grown in orchards and 54,000 tons on standard trees (Schweizer Obstverband, 2019). Around 85% of the apples grown in orchards sold as dessert fruits, the remaining 15% as processed fruit (e.g., apple juice, apple juice concentrate). Almost all apples grown on standard trees only had use as processed fruit (Schweizer Obstverband, 2019). On average between 2009 and 2019, the production of apples for processing amounted to 81,000 tons.

On average, imported dessert apples make up only 10% of Switzerland’s total consumption (Schweizer Obstverband, 2021). The average annual production of 130,000–140,000 tons can cover demand between the beginning of harvest in August and June of the following year, when warehouses empty out. Experience shows that traders import around 10,000 tons of dessert apples between May and August (Schweizer Obstverband, 2021). Between 2009 and 2019,

the largest supplying countries were Italy, New Zealand, France and Chile (Eidgenössische Zollverwaltung, 2021). Fruit from neighboring countries as well as the southern hemisphere covers thereby the local market gap in summer (Schweizer Obstverband, 2021). The low yield of 2017, when many Swiss regions were struck with frost damage, explains the large import of around 26,500 tons in 2018. Due to high production costs in Switzerland, exports of fresh apples only play a minor role, with an average of around 4,000 tons between 2009 and 2019, mostly into neighboring countries like Germany, Austria and France (Eidgenössische Zollverwaltung, 2021).

TURKEY

Statistical overview

Apple has a high production quantity following grape production in Turkey (TurkSTAT, 2020). It covers 5% of Turkey’s fruit production areas and accounts for 18% of total fruit production. According to estimations from the Turkish Statistics Institute (TurkSTAT, 2020), 3,618,752 tons of apples were grown on 174,439 ha of land. Ecological suitability, high adaptation ability of apple, and a profitable production branch for growers are the main reasons for the high production (Karamürsel et al., 2011). The apple production area and quantity increased by 7% and 23%, respectively, over the last ten years (2009–2019) (Figure 24). Despite fluctuations in apple production caused by spring frost in some years, the harvested area has steadily increased. Spring frost damage was particularly severe in 2014 and 2015. The damage was regionally effective, and yield decreased in the provinces of Karaman, Niğde, and Kayseri (Öztürk et al., 2015).

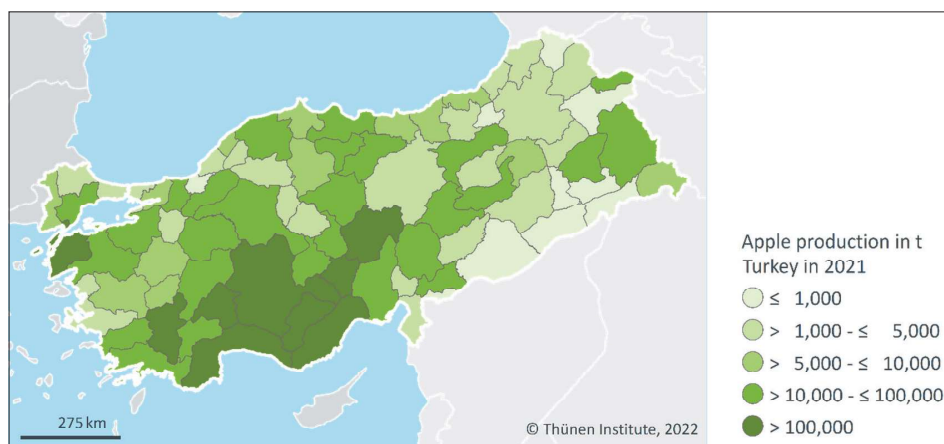


FIGURE 25. Main producing regions and production quantity in Turkey (2019). Source: Cografyaharita (2020).

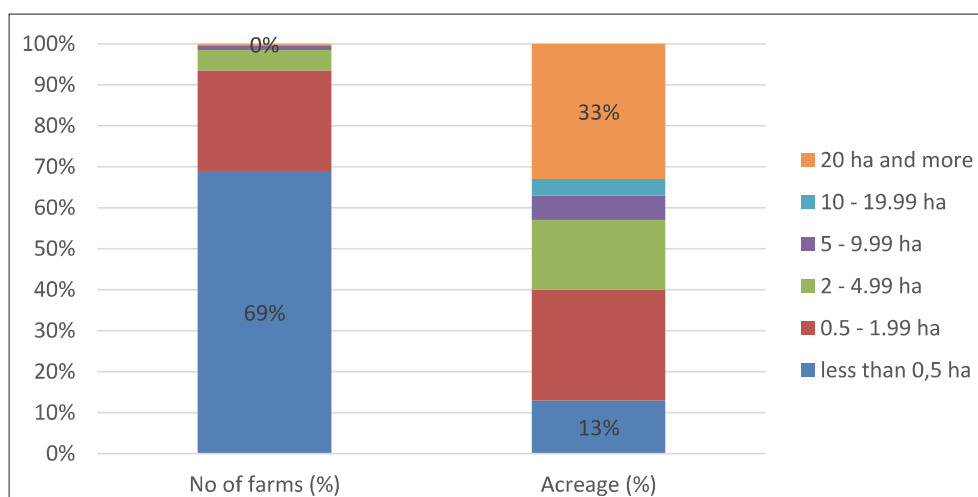


FIGURE 26. Distribution of number of farms and production area according to size of apple cultivation area in Turkey, 2020. Source: BUGEM (2020).

The majority of production is still done using traditional methods. In recent years, there has been an increase in commercial production areas' interest in intensive growing methods and new varieties. Since 2009, one of the indicators of this situation has been the increase in production quantity (30%), which has been greater than the increase in area (7%) (Figure 24). Higher yields per unit area have been achieved through transformation in orchard systems. However, due to the small scale of apple production areas and financial problems, the speed of conversion to modern cultivation methods is very slow.

Apple producing regions in Turkey

Turkey is located within the borders of Asia Minor and the Mediterranean gene centers, which are referred to as the apple center of origin, and Anatolia is one of the gene centers. Apples can be grown throughout the country due to favorable climatic conditions. As a result, apple cultivation is practiced in nearly all of Turkey's provinces. However, the majority of apple production in Turkey is concentrated in seven provinces: Isparta, Karaman, Niğde, Antalya, Kayseri, Konya, and Denizli (Figure 25). These regions constitute 61% of the total apple production area, and their share in production is 71%. Isparta is a significant apple producing region in Turkey. It accounts for 20% of total production and 13% of total production area. Apple production is composed of about 95% of the total fruit area. Isparta also has a significant infrastructure in terms of storage, packaging systems, processing, and research and development. In other respects, remarkable developments are taking place in the provinces of Karaman and Niğde as a result of newly established plantations, large orchard areas, and expanding industrial infrastructure.

Apple production area and number of farms are registered in the Ministry of Agriculture and Forestry "Farmer Registration System (FRS)", grouped as percentage share according to size of apple cultivation area. 69% of the farms are smaller than 0.5 ha (Figure 26). The rate of farms with larger apple production areas in Isparta, Karaman, Niğde, and Kayseri is higher than in other provinces. Farmers with apple acreage less than 10 ha represented 64% of the total apple production area, according to the FRS. The proportion of apple production areas of 20 ha or more is higher in Konya, Niğde, and Karaman provinces than in other production regions. These provinces' suitable farmlands and capital factors enable intensive farming in larger areas. Farmlands have a multi-part structure because inheritance law previously allowed lands to be divided into very small parts. Legal regulations gover-

ning the protection of land size have been put in place in recent years. As a result of land consolidation efforts, operating parcel sizes are expected to grow.

Important apple varieties and marketing channels

72% of Turkey's apple production area comprises the 'Red Delicious' group, 'Golden Delicious', 'Granny Smith', and 'Amasya' varieties (TurkSTAT, 2020). 'Red Delicious' groups are quite popular among other varieties. Unlike other provinces, 'Amasya' variety constitutes 40% of the production area and 32% of the production quantity in Niğde province. 'Amasya' is an important native apple variety with excellent eating quality. However, it shows alternate bearing. Turkey has a significant number of native apple cultivars that have persisted to the present day. 'Amasya Misket', 'Kağızman Uzun', 'Yomra', 'Piraziz' and 'Posof-Badele' apples are among the varieties that have received geographical indications.

The majority of apples are consumed fresh in the domestic market; however, some are utilized as a raw material in the processing industry, such as fruit juice, fruit concentrate, dried apple, and other products. Although apples can be consumed fresh throughout the year because to controlled atmosphere cold storage and the application of 1-MCP, the most intense seasons for consumption are autumn and winter. Many marketing channels are used in apple sales, but merchants have the largest share of all fruit categories.

Turkish apple imports and exports

Apple imports are extremely low because the country is self-sufficient in apple production. Imports are made when domestic supplies are depleted or when special varieties are required. In 2019, Turkey imported 1,731 tons of apples. Chile and Iran accounted for the majority of total apple imports between 2017 and 2019 (FAO, 2020). In 2019, 7% (257,471 tons) of the apples were exported. Iraq accounts for a sizable portion of apple exports. In 2017–2019, 47% of exports were made to Iraq, while 36% to Syria, Russia, India, and Saudi Arabia (FAO, 2020).

Discussion

In nearly all countries included in this overview, apples are the most important fruit crop with regards to production area and harvested quantity. The global trend of increasing apple production can be confirmed also for most of the apple producing countries in Europe. Apple acreage has been stable or even increasing in Austria, Germany, Italy, Poland Portugal and Turkey, however, in Czech Republic and Hungary it

has been decreasing in the past ten years. Typically, there are geographical clusters for apple production in each country, where natural growing conditions are favorable and specialized infrastructure in terms of production technology, farmer organizations, input markets, storage facilities and access to markets are available, which has positive effects for competitiveness.

There are major differences with respect to the use of modern production technologies, which are related to the diverging trends in apple production in the different countries. Although traditional production systems with tall and often old trees and low planting densities can be found in all European countries, the major share of marketed fresh apples in Austria, Germany, Italy, Switzerland and Poland is harvested in modern high-density orchards. In Poland, in the recent decades, large investments in modernizing orchards have been made, supported by policies and strengthening of producer organizations, leading to significant increases in productivity and the position as major apple producing country in Europe. In Turkey, traditional apple production systems are still prevailing. Yet there is also a trend towards modernization, particularly in regions with larger farm structures and favorable climate and soil conditions. In Czech Republic as well as in Hungary, low profitability of apple orchards, related to a low technology level, lack of irrigation and storage facilities, represents a major challenge for the sector and has led to aging orchards and declining production area.

The findings of this overview show that apple production in Europe is mainly a business of small- to medium-scale farmers. In all countries, except Germany, much more than 50% of apple acreage belongs to farms with less than 20 ha, in most cases even less than 10 ha. However, there are also differences in typical farm sizes between the countries, as is explained for Italy, Germany and Turkey. Yet, there seems to be a general trend towards larger farms.

Considering the market orientation, two groups of countries can be identified. In Poland and Italy, there is a clear export orientation of the apple sector. Neighboring European countries are the main destinations for their exported apples, but significant quantities also are sold to Middle East and Northern African countries. Also, Turkey is a net exporter of apples, although the major share of production is consumed within the country. In the other countries, apples are mainly sold on domestic markets; additionally, imports are needed to satisfy national demand.

Only scarce data are available on organic apple production. According to statistics from Austria, Italy and Hungary, the share of organic apple acreage is still low, but significantly increasing over the past years. As an example, in Austria the organic apple production area has doubled since 2012 and now accounts for 22% of the total apple area (Statistik Austria, 2018). It is likely, that in other European countries, a similar development is taking place.

Apple production quantities have shown great variation over the past ten years, which is a common pattern for apple production. However, in most countries, significant effects were reported from extreme weather events, such as spring frost, drought conditions and hail events. Climate change can lead to increasing risks and costs for fruit production, if the frequency of extreme adverse weather events increases. Also, increasing pressure from pests and diseases may affect quantity and quality of the apple harvest in all countries. This is in line with findings that other authors made (e.g., Pfeleiderer et al., 2019; Gömann et al., 2015; Li et al., 2020). For a better crop protection and to reduce their economic risk,

apple farmers use measures such as hail nets, frost irrigation, insurance and plant protection measures. The application of these measures became increasingly important during the last years (Porsch et al., 2018) and is forecasted to gain further importance.

Conclusions

The overview of nine major European apple producing countries reveals a diverse picture of development trends and of challenges for the apple sectors. There are similarities with respect to the importance of regional production clusters, the production in rather small to medium sized farms and a trend towards larger farm structures over time.

In all countries, mitigation of climate risks is a major challenge for apple producers. However, the access to and the level of use of modern production technologies is still a challenge for some of the countries. Lack of capital for investment in orchard renewal, lack of irrigation infrastructure and modern storage technology are constraints for improving the competitiveness.

On the opposite, strong support to producer organizations and investment in new orchards and varieties that are demanded on international markets, as well as investment in post-harvest and storage technologies have contributed to the strong competitive position of the Italian and the Polish apple sectors.

The overview provided in this paper can be the starting point for a detailed comparative study of apple value chains in European countries, which should focus first on the farm level with an economic analysis of the production systems.

Acknowledgments

The figures and maps were edited by Elke Burghard-Tiede at the Thünen-Institute.

References

- Apáti, F. (2009). The comparative economic analysis of Hungarian and German apple production of good standard. *Intl. J. Hortic. Sci.* 15(4), 79–85. <https://doi.org/10.31421/IJHS/15/4/847>.
- Bio Garancia (2021). Personal communication.
- Blanke, M. (2011). Obstkonsum in China – Anbau, Angebot und Preise. *Erwerbs-Obstbau* 53, 93–98. <https://doi.org/10.1007/s10341-011-0139-2>.
- Blanke, M. (2017). Apfel oder Acai: Brasiliens Obstbau im ökonomischen und klimatischen Wandel. *Erwerbs-Obstbau* 59, 245–252. <https://doi.org/10.1007/s10341-017-0328-8>.
- Blanke, M. (2021). Obstbau-Boom in Russland dank staatlicher Förderung, Gesundheitstrend und Umstrukturierung der Obstbauforschung. *Erwerbs-Obstbau* 63, 37–45. <https://doi.org/10.1007/s10341-020-00533-7>.
- Bravin, E., Carint, D., Dugon, J., Hanhart, J., and Steinemann, B. (2011). Schweizer Kernobstproduktion unter der Lupe – Ein Rückblick auf strukturelle und betriebswirtschaftliche Daten. (Changins-Wädenswil, Switzerland: Agroscope).
- Buchtová, I. (2019). SITUAČNÍ A VÝHLEDOVÁ ZPRÁVA. OVOCE (Prague, Czechia: Ministerstvo zemědělství).
- Buchtová, I. (2020). SITUAČNÍ A VÝHLEDOVÁ ZPRÁVA. OVOCE (Prague, Czechia: Ministerstvo zemědělství).
- BUGEM (2020). Republic of Turkey Ministry of Agriculture and Forestry, General Directorate of Plant Production. <https://www.tarimorman.gov.tr/BUGEM/> (accessed February 23, 2021).

- Bundesamt für Landwirtschaft (2020). Statistiken Obst. <https://www.blw.admin.ch/blw/de/home/nachhaltige-produktion/pflanzliche-produktion/obst/statistiken-obst.html> (accessed February 2, 2021).
- Cografyaharita (2020). Türkiye Elma Üretim Haritası 2019. <http://cografyaharita.com/turkiye-tarim-haritalari4.html> (accessed February 10, 2021).
- Destatis (2017). Baumobstanbauerhebung 2017 (Wiesbaden, Germany).
- Destatis (2020). Wachstum und Ernte – Baumobst. https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Landwirtschaft-Forstwirtschaft-Fischerei/Obst-Gemuese-Gartenbau/Publikationen/Downloads-Obst/obst-jahr-2030321197144.pdf?__blob=publicationFile (accessed June 25, 2020).
- DGADR (2021). Portuguese Traditional Products. Agricultural products, foodstuffs and prepared dishes. <https://tradicional.dgadr.gov.pt/en/> (accessed May 5, 2021).
- Eidgenössische Zollverwaltung (2021). SwissImpex Version 3.8.1-41. <https://www.gate.ezv.admin.ch/swissimpex/index.xhtml> (accessed February 1, 2021).
- Ekinci, K., Demircan, V., Atasay, A., Karamursel, D., and Sarica, D. (2020). Energy, economic and environmental analysis of organic and conventional apple production in Turkey. *Erwerbs-Obstbau* 62, 1–12. <https://doi.org/10.1007/s10341-019-00462-0>.
- European Commission (2020a). Apples Statistics (prices, production, trade). https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/markets/overviews/market-observatories/fruit-and-vegetables/pip-fruit-statistics_en (accessed August 30, 2021).
- European Commission (2020b). Fruit and vegetables market observatory. https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/markets/overviews/market-observatories/fruit-and-vegetables/pip-fruit-subgroup_en (accessed August 30, 2021).
- Eurostat (2020). Structure of Orchards and Vineyards. <https://ec.europa.eu/eurostat/web/agriculture/data/database> (accessed September 2, 2020).
- FAO (2020). FAOSTAT database 2020. <http://www.fao.org/faostat/en/#data/QC> (accessed June 24, 2020).
- FAO (2021). FAOSTAT database 2021. <http://www.fao.org/faostat/en/#data/QC> (accessed April 20, 2021).
- FAO, and WHO (2004). Fruit and vegetables for health. Report of a Joint FAO/WHO Workshop, Kobe, Japan, 1–3 September 2004 (Geneva, Switzerland: World Health Organization).
- FAODataLab. (2021). FAO Big Data tool on Covid-19 impact on food value chains. <http://www.fao.org/datalab/> (accessed August 30, 2021).
- Ferreira, V., Ramos-Cabrer, A.M., Carnide, V., Pinto-Carnide, O., Assunção, A., Marreiros, A., Rodrigues, R., Pereira-Lorenzo, S., and Castro, I. (2016). Genetic pool structure of local apple cultivars from Portugal assessed by microsatellites. *Tree Genetics & Genomes* 12. <https://doi.org/10.1007/s11295-016-0997-8>.
- FruitVeB (2020). Fruitveb Bulletin 2019 – Gyümölcsstermesztés III. <https://fruitveb.hu/fruitveb-bulletin-2019-gyumolcstermesztes-iii-resz/> (accessed February 26, 2021).
- GAIN (2020a). China Fresh Deciduous Fruit Annual Report 2020 (Beijing).
- GAIN (2020b). EU Fresh Deciduous Fruit Annual Report 2020 (Berlin).
- GAIN (2020c). Russia Fresh Deciduous Fruit Annual Report 2020 (Moscow).
- Garming, H., Dirksmeyer, W., and Bork, L. (2018). Entwicklungen des Obstbaus in Deutschland von 2005 bis 2017: Obstarten, Anbauregionen, Betriebsstrukturen und Handel (Braunschweig, Germany: Thünen Institute).
- Golombek, S., and Blanke, M. (2020). Vom Fuße des Himalaya – Wertschöpfungskette Äpfel in Indien. *Erwerbs-Obstbau* 62, 377–387. <https://doi.org/10.1007/s10341-020-00515-9>.
- Gömann, H., Bender, A., Bolte, An., Dirksmeyer, W., Englert, H., Feil, J.-H., Frühauf, C., Hauschild, M., Krengel, S., Lilienthal, H., and Löpmeier, F.-J., et al. (2015). Agrarrelevante Extremwetterlagen und Möglichkeiten von Risikomanagementsystemen. Studie im Auftrag des Bundesministeriums für Ernährung und Landwirtschaft (BMEL) (Braunschweig, Germany: Thünen Institute).
- Gooch, M., Stiefelmeyer, K., Marenick, N., and Borovilos, G. (2012). Horticulture Value Chain Roundtable Benchmarking Study for Canadian Apples (Burnaby, Canada: Miscellaneous Publications).
- GPP (2006). Crop Production Yearbook.
- GUS (2019). Rocznik Statystyczny. Rolnictwa 2019. <https://stat.gov.pl/obszary-tematyczne/roczniki-statystyczne/roczniki-statystyczne/rocznik-statystyczny-rolnictwa-2019,6,13.html> (accessed October 10, 2021).
- Hochstamm Suisse (2021). Hochstamm Suisse – Früchte, Geschichte, Bedeutung und Biodiversität. https://www.hochstamm-suisse.ch/wp-content/uploads/2018/10/Hochstamm_Suisse_Bedeutung_web.pdf (accessed February 1, 2021).
- Hungarian Payment Agency (2021). Personal communication.
- INE (2020). Instituto Nacional de Estatística. Statistics Portugal.
- INE (2021). Instituto Nacional de Estatística. Statistics Portugal.
- Jafta, A. (2014). Analysing the competitiveness performance of the South African apple industry. M.Sc. thesis in Agriculture (Stellenbosch, South Africa).
- Karamürsel, D., Öztürk, F.P., and Emre, M. (2011). Elma Kültürü: Global Elma Endüstrisi ve Üretim Ekonomisi. In *Bahçe Kültürleri Araştırma Enstitüsü Müdürlüğü*, H. Akgül, E. Kaçal, F.P. Öztürk, Ş. Özongun, A. Atasay and G. Öztürk, eds. (Eğirdir: Bahçe Kültürleri Araştırma Enstitüsü Müdürlüğü).
- Központi Statisztikai Hivatal (2017). Gyümölcsültetvények összeírása. https://www.ksh.hu/agrarcentzusok_ultetvenyek (accessed February 26, 2021).
- Központi Statisztikai Hivatal (2020a). Fontosabb gyümölcsfélék és a szőlő betakarított területe. http://www.ksh.hu/stadat_files/mez/hu/mez0014.html (accessed February 26, 2021).
- Központi Statisztikai Hivatal (2020b). Gyümölcsstermelés megye és régió szerint. https://www.ksh.hu/stadat_files/mez/hu/mez0086.html (accessed February 26, 2021).
- Lang, M., and Prantl, A. (2018). Kosten im Apfelnbau. Betriebswirtschaftliche Kennzahlen für den Südtiroler Apfelnbau, Ausgabe 2018–2019 (Lana, Italy).
- Li, M., Guo, J., He, J., Xu, C., Li, J., Mi, C., and Tao, S. (2020). Possible impact of climate change on apple yield in Northwest China. *Theor. Appl. Climatol.* 139, 191–203. <https://doi.org/10.1007/s00704-019-02965-y>.
- Mateus, R., Duarte, A., and Marreiros, A. (2020). Identificação de variedades tradicionais de macieira associadas à designação “Pêro de Monchique”. *Actas Port. Hortic* 32, 269–276.
- Menghi, A., Roest, K. de, Porcelluzzi, A., Deblitz, C., Davier, Z. von, Wildegger, B., Witte, T. de, Strohm, K., Garming, H., and Dirksmeyer, W., et al. (2015). Assessing farmers’ costs of compliance with EU legislation in the fields of environment, animal welfare and food safety. Final Report (Brussels, Belgium: European Commission).

- Oğuz, C., and Karaçayır, H.F. (2009). Türkiye’de Elma Üretimi, Tüketimi, Pazar Yapısı ve Dış Ticareti. *Intl. J. Agric. Nat. Sci.* 2, 41–49.
- Öztürk, F.P., Emre, M., and Karamürsel, D. (2015). Elma, Tarımsal Araştırmalardan Bakış (TEPGE Yayın).
- Pfleiderer, P., Menke, L., and Schleussner, C.-F. (2019). Increasing risks of apple tree frost damage under climate change. *Climatic Change* 157, 515–525. <https://doi.org/10.1007/s10584-019-02570-y>.
- Pietrzak, M., Chlebicka, A., Kraciński, P., and Malak-Rawlikowska, A. (2020). Information asymmetry as a barrier in upgrading the position of local producers in the global value chain – Evidence from the apple sector in Poland. *Sustainability* 12, 7857. <https://doi.org/10.3390/su12197857>.
- Porsch, A., Gandorfer, M., and Bitsch, V. (2018). Strategies to manage hail risk in apple production. *Agric. Finance Rev.* 78, 532–550. <https://doi.org/10.1108/AFR-07-2017-0062>.
- Retamales, J.B., and Sepúlveda, J.C. (2011). Fruit production in Chile: Bright past, uncertain future. *Rev. Bras. Frutic.* 33, 173–178. <https://doi.org/10.1590/S0100-29452011000500020>.
- Roszik, P. (2021). JELENTÉS A BOKONTROLL HUNGÁRIA 2020 (Budapest, Hungary: Biokontroll Hungaria).
- Schwartau, H. (2018). Obstbau weltweit, in Europa und in Deutschland. In Lucas’ Anleitung zum Obstbau, M. Büchele, ed. (Stuttgart (Hohenheim): Ulmer), p. 13–17.
- Schweizer Obstverband (2019). Ernteschätzung 2019 – Äpfel und Birnen.
- Schweizer Obstverband (2020). Ernteschätzung 2020 – Apfel- und Birnenanlagen in der Schweiz.
- Schweizer Obstverband (2021). Wie viele Äpfel werden in die Schweiz importiert? <https://www.swissfruit.ch> (accessed February 1, 2021).
- Statistik Austria. Obst aus Erwerbsobstanlagen 1975–2020. https://www.statistik.at/web_de/statistiken/wirtschaft/land_und_forstwirtschaft/agrarstruktur_flaechen_ertraege/obst/index.html (accessed March 15, 2021).
- Statistik Austria (2018). Erhebung der Erwerbsobstanlagen 2017 (Vienna, Austria).
- Statistik Austria (2020a). Obsternte Kalenderjahr 2020. Schnellbericht. 1.14 (Vienna, Austria).
- Statistik Austria (2020b). Obstproduktion aus Erwerbsobstanlagen. Endgültiges Ergebnis 2020 (Vienna, Austria).
- TurkSTAT (2020). Turkish Statistical Institute. <https://biruni.tuik.gov.tr/medas/> (accessed December 24, 2020).
- UN Comtrade (2020). UN Comtrade Database 2020. <https://comtrade.un.org/data/> (accessed November 18, 2020).
- UN Comtrade (2021). UN Comtrade database 2021. <https://comtrade.un.org/data/> (accessed April 20, 2021).
- United Nations (2015). Transforming Our World: The 2030 Agenda for Sustainable Development (New York, U.S.A.: UN Publishing).
- United Nations (2019). World Population Prospects (New York, U.S.A.: UN Publishing).
- USDA (2020). Fresh Apples, Grapes, and Pears: World Markets and Trade June 2020. World Production, Markets, and Trade Reports.
- Vasylyeva, N., and James, H. (2021). Production and trade patterns in the world apple market. *Innovative Marketing* 17, 16–25. [https://doi.org/10.21511/im.17\(1\).2021.02](https://doi.org/10.21511/im.17(1).2021.02).
- Wurm, L. (2021). Obstbau unter sich ändernden Rahmenbedingungen. Chancen und Risiken. *Berichte über Landwirtschaft* 99, 1–24.
- Zhang, Q., Shi, F., Abdullahi, N.M., Shao, L., and Huo, X. (2020). An empirical study on spatial-temporal dynamics and influencing factors of apple production in China. *PloS ONE* 15, e0240140. <https://doi.org/10.1371/journal.pone.0240140>.
- Żurawicz, E., Kubik, J., Lewandowski, M., Rutkowski, K.P., and Zmarlicki, K. (2019). The apple industry in Poland. *Acta Hortic.* 1261, 13–20. <https://doi.org/10.17660/ActaHortic.2019.1261.3>.

Received: Jan. 12, 2022

Accepted: Jul. 22, 2022

Addresses of authors:

- Anika Muder^{1*}, Hildegard Garming¹, Sabrina Dreisiebner-Lanz², Katharina Kerngast², Franz Rosner³, Kristýna Kličková⁴, Gyongyi Kurthy⁵, Katalin Cimer⁵, Aldo Bertazzoli⁶, Valeria Altamura⁷, Giorgio De Ros⁸, Krzysztof Zmarlicki⁹, Maria de Belém Costa Freitas¹⁰, Amílcar Duarte¹⁰, Esther Bravin¹¹, J. Kambor¹¹, Dilek Karamürsel¹², Fatma Pınar Öztürk¹² and Emel Kaçal¹²
- ¹ Thünen-Institute of Farm Economics, Bundesallee 63, 38116 Braunschweig, Germany
 - ² Joanneum Research Forschungsgesellschaft mbH, LIFE – Institute for Climate, Energy and Society, Waagner-Biro-Straße 100, 8020 Graz, Austria
 - ³ Höhere Bundeslehranstalt und Bundesamt für Wein- und Obstbau Klosterneuburg, Wiener Straße 74, 3400 Klosterneuburg, Austria
 - ⁴ Institute of Agricultural Economics and Information, Mánesova 1453/75, 120 00 Praha 2, Czech Republic
 - ⁵ Institute for Agricultural Economics, Budapest, 1093, Zsil u. 3-5, Hungary
 - ⁶ DISTAL – University of Bologna; viale G. Fanin, 50, 40127 Bologna (BO), Italy
 - ⁷ Crop Production Research Centre (C.R.P.V.), 47522 Cesena (FC), Italy
 - ⁸ Technology Transfer Centre; Fondazione Edmund Mach (FEM), 38010 San Michele all’Adige (TN), Italy
 - ⁹ Instytut Ogródnictwa – PIB / The National Institute for Horticultural Research, ul. Konstytucji 3 Maja 1/3, 96–100 Skierniewice, Poland
 - ¹⁰ Algarve University, MED - Mediterranean Institute for Agriculture, Environment and Development, Campus de Gambelas, Edf. 8, 805–139 Faro, Portugal
 - ¹¹ Agroscope, Müller-Thurgaustrasse 29, 8820 Wädenswil, Switzerland
 - ¹² Fruit Research Institute, Kızılcubuk Street PK: 2, 32500 Eğirdir/Isparta, Turkey
- * Corresponding author; E-mail: anika.muder@thuenen.de

