The Wizards of Svalöf; Intellectual property rights and consolidation in the plant breeding industry

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This paper reviews the most prominent changes that have taken place in the plant breeding industry in Sweden. We argue that the establishment of Intellectual Property Rights schemes creates power asymmetry in the seed value chain and has therefore been a major driver of consolidation in Sweden and internationally. Furthermore, we provide an assessment of the use of cultivars bred domestically. This has been achieved by identifying and classifying the variety owners for major crops based on the origin of the breeding station and calculating the percentage of the domestically-bred varieties used in crop production. The ratio of local varieties in relation to imported varieties is of special significance to Sweden, which has a long history of plant breeding and a challenging climate.

Key words: biotechnology, UPOV, seed industry, seed system, trade agreements, value chain

Introduction

The hot and dry summer of 2018 was problematic for agriculture in Northern European countries, including Sweden. The country received less rainfall than the expected annual level, leaving Swedish farmers with substantial losses. As a result of the crisis, Sweden turned to the European Commission and asked for emergency aid support. A few months later, the government presented a package of SEK 1.2 billion *to cover the fodder shortage and other loss of income that farmers are experiencing due to the drough*t (Government Offices of Sweden 2018).This unusually warm and dry summer is likely to be repeated. The global mean surface temperature is expected to rise by up to 1.5 °C in the coming decades (IPCC 2018). Changes in rainfall patterns combined with prolonged growth seasons could result in increased pressure from diseases and pests (Eriksson et al. 2018).

A question arises among experts as to whether the Swedish food system can maintain its capacity in the future without compromising the national level of food self-sufficiency. Plant biotechnology has improved farm income by boosting yields while reducing the need for other inputs, such as fertilizers and pesticides. Additionally, research shows that agricultural biotechnology also reduces greenhouse gas emissions and soil erosion (Zilberman et al. 2018). Therefore, plant biotechnology is a valuable tool for a country to mitigate the impact of climate change, safeguard biodiversity and achieve the UN's sustainability development goals (FAO 2018).

Sweden has a long tradition of plant breeding; in 1886 two prominent landowners established a society for cultivation and breeding of plants (Sydsvenska Förening för Odling och Förädling af Utsäde) which was the beginning of the formation of a strong scientific cluster in Svalöf-Lanskrona (Nilsson and von Bothmer 2010). Decades later, plant breeders in Sweden earned the title of the "Wizards of Svalöf", by conducting path-breaking work in this small town in the southernmost province of Sweden and taking the country to the forefront of plant breeding globally (USDA 1948). Characteristically, a major Swedish plant breeding and seed organization during 1990s had 50% of the Canadian market in breeding and marketing varieties of oil seed crops while had global presences with 17 subsidiary companies in Germany, Spain, Argentina, France, United Kingdom, The Netherlands, Italy and Denmark (Kuylenstjerna 1997, Svensson and Weibull 1997).

However, in recent decades, Sweden has lost its leadership role in this arena – and the ability to control the domestic market. For example, over the years, the number of Swedish-bred varieties registered on the National List of Plant Varieties has been constantly decreasing (Solberg and Breian 2015). Although the number of plant breeding organizations in Sweden has not changed significantly the last decades, domestic breeding programmes have been significantly reduced and are now dependent on collaboration with multinational corporations.

Globally, the seed industry is dominated by only four multinational corporations: Bayer, which has acquired Monsanto; Chem-China, which owns Syngenta; Corteva (formerly Dow and DuPont); and BASF (Bonny 2017). A crucial driver behind this consolidation was the emergence of biotechnology. Modern breeding techniques reinforced

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the establishment and enforcement of Intellectual Property Rights (IPRs). IPRs can block product development and generate “patent thickets”. As the interdependency among plant breeders on contractual licensing arrangements was increasing, mergers and acquisitions (M&A), both domestically and internationally, provided a way to aggregate and control the relevant IPRs (Nilsson 2007, Howard 2015, Lianos et al. 2016, Hendrickson et al. 2019).

The level of concentration in the global seed industry has attracted much attention from policy makers, researchers and consumer groups. Previous research has investigated the link between IPRs, consolidation and ownership structures (for example full ownership, joint ventures, etc.) for major actors on a global scale (Howard 2009, 2015, Lianos et al. 2016, Bonny 2017). To the best of our knowledge, no attempt has been made to map the M&A that have taken place in the Swedish seed industry, or their impact on the use of Swedish-bred cultivars.

In this study, we use the global value chain framework (Gereffi et al. 2005, Gereffi and Lee 2012) to describe how IPRs create power structures in the plant breeding/seed value chain in Sweden. Our objective is twofold: first, to document the evolution of the plant breeding industry in Sweden and second, to provide an assessment of the use of cultivars bred domestically. We believe that this study is the first to investigate the impact resulting from changes in global and domestic organizational, political and regulatory environments on the evolution of the Swedish plant breeding industry through the lens of the global value chain.

Material and methods

Methodology and data

The global value chain framework is used to describe the governance configuration that encompasses the Swedish plant breeding industry. We argue that the tightening of IPR laws created market power in the upper part of the chain and increased the concentration in the industry, spurring waves of M&A. It has therefore been a crucial determinant of the evolution of plant breeding in Sweden. We have documented and sketched this evolution in Sweden by reviewing major M&A for the most prominent organizations since the emergence in the 1880s of early domestic breeding programmes. In order to achieve this, we conducted a review of the scientific literature on the subject, as well as material from annual reports, presentations for shareholders, conference presentations, seminars, public speeches and newspapers. We conducted interviews with breeders, farmers, seed multipliers and representatives of breeding organizations and performed a qualitative content analysis. This approach provides the flexibility of using a combination of inductive and deductive approaches to data analysis (Cho and Lee 2014) and facilitates the generation of themes that provide evidence of the structural changes that have taken place over the last 130 years and which have transformed the plant breeding industry (Berg 2001).

Lastly, we have attempted to quantify an aspect of the governance configuration by calculating the current level of dependence on foreign-bred varieties. As a first step, we used new entries of cultivars listed in the national catalogue, and new grants published in the annual list of Swedish Plant Breeders’ Rights as a means of extracting information on the historical development of new cultivars in Sweden. The primary source of this information is the Official National Varieties List from the Swedish Board of Agriculture and UPOV-PLUTO plant variety database respectively. An examination of the numbers of varieties listed, either in terms of the total number of Swedish-bred cultivars listed each year or the total number of annual new entries in the list, provides insightful information regarding the evolution of plant breeding and crop diversity in Sweden. However, it neglects the extent of dependence on foreign-bred varieties. Thus, as a next step, the percentage of production of certified seed originating from Swedish-bred varieties has been calculated. The data on production of certified seed were retrieved from the Swedish Board of Agriculture (2014, 2015, 2016) and combined with data from the Community Plant Variety Office and PLUTO databases, in which we retrieved information on the origin of the breeding station of each cultivar. This complementary approach allowed us to control for older varieties still present in the national list, which are however, less relevant to agricultural production.

Concepts and framework

Issues related to agri-food industries and the changes brought about by the emergence of global food value chains have gained much attention. Sustainable diets, food security, environmental protection and climate change are some of the challenges that agricultural systems must address (Vorley 2001, Humphrey and Memedovic 2006, Gereffi et al. 2009, Bosona and Gebresenbet 2013, Gelli et al. 2015). Gereffi et al. (2005) have identified five global value chain governance structures in which the degree of explicit coordination and the power of asymmetry increases as when moving from one mode to the next. Figure 1 is based on global value chain typology (Gereffi et al. 2005) and aims to explain the seed value chain in Sweden, starting with plant breeders, moving on to intermediate consumers, farmers and, lastly, to end consumers. The graph provides a current "snapshot" of the chain today and represents the outcome of constant transformations in the governance of both the domestic and the global value chains (Gereffi et al. 2005, Gereffi and Lee 2012).

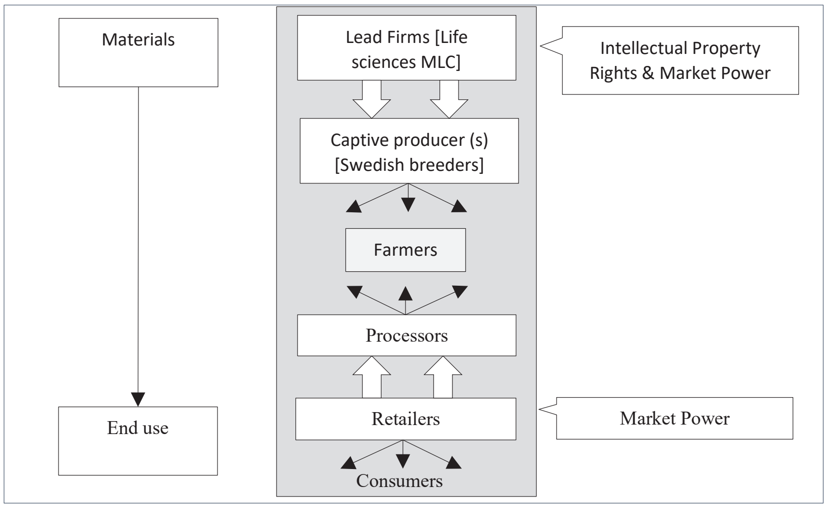

Fig. 1. Illustration of seed value chain: Captive structure

At the center of the chain are the farmers. The "lower" part of the chain depicts farmers in their downstream network (processors and retailers) and corresponds to the downstream captive mode. Typically, small producers (farmers and processors) depend on larger buyers (retailers). Sweden has 3593 food processing companies, 99% of which are small and medium-sized enterprises (Eriksson et al. 2016). The retail market is the most concentrated market in Europe. The largest retailer has 50% of the market while the top three retailers have a combined market share of 86% (Gullstrand and Jörgensen 2012, Eriksson et al. 2016).

The focus of this paper is the "upper" segment of the chain, specifically the interaction between a handful of Swedish breeders and a few international biotech companies. This network exhibits characteristics of an upstream captive value chain. A few Swedish plant breeders are dependent on large Life Science Multinational Corporations (MLC) that determine the distribution of profits among the actors in the chain (Gereffi and Lee 2012, Lee and Gereffi 2015, Hendrickson et al. 2019). One main source of this power asymmetry is the establishment and enforcement of Intellectual Property Rights (IPRs). In captive value chains, the high level of dependency in the network is usually attributable to relation-specific investments (Gereffi et al. 2005). In plant breeding, as in other producer-driven chains, intangible assets (for example patents) make switching difficult, if not impossible (Dallas et al. 2019).

IPRs can be defined as *rights granted by a state authority for certain products of intellectual effort and ingenuity* (Prifti 2015 p. 31). The most prominent IPRs in plant biotechnology are patents and Plant Breeders' Rights (PBR). Despite their differences (see Supplemental Table), IPRs serve a two-fold purpose. First, to ensure that innovators will be able to appropriate the value of the return on their investment in R&D and, secondly, to prohibit the use of trade secrets or similar means of protection which, unlike PBR and patents, do not disclose information on protected material, thereby blocking further innovation.

IPRs have the power to shape structural relations in the global seed industry. Specifically, they increase concentration and create power asymmetry in the chain through two main mechanisms. First, by prohibiting new firms from entering the market (Kalaitzandonakes and Bjornson 1997, Louwaars et al. 2009). Plants can be viewed as *datasets that breeders manipulate to express particular characteristics* (Blakeney 2011 p.16). Seed germplasm with the desired traits and attributes is used to obtain the next generation of plants with the best characteristics. Plant varieties, gene traits, breeding technologies and methods can be protected by IPRs. The development of an innovation relies on permission to use technology or genetic material that is protected by IPRs. Thus, access to intellectual property acts as a barrier to R&D, innovation or the product market (Oehmke and Wolf 2003). Intellectual property lawsuits in agricultural inputs industries are so common that it is difficult for a new product to reach the market without a potential patent infringement (Maisashvili et al. 2016). Infringement litigation can amount to a range of several millions dollars and therefore even the threat of litigation can deter smaller firms and start-ups from entering (Lesser 1999, Maisashvili et al. 2016).

Second, IPRs increase concentration by creating pressure and financial incentives for vertical integration, strategic alliances, contracting and various types of licensing agreements among existing firms. Biotech firms that wish to produce and deliver seeds to farmers take advantage of reduced transaction costs and economies of coordination and opt to vertically integrate downstream with traditional firms in order to access a good quality seed base and marketing channels (Lesser 1999, Shi 2009). The alternative to this approach for biotech firms is to license protected technologies to seed companies. The collection of royalties from licensing agreements, a practice known as "non-merger mergers", paved the way for many of the buy-outs (Maisashvili et al. 2016). Such arrangements act in a manner similar to the formation of an industry cartel: smaller companies with smaller biotech capacities must either merge with the larger companies, license from them, or exit the market (Maisashvili et al. 2016). Increased concentration in the industry has also been linked to the settlements of intra-industrial conflicts. A patent claim on transgenic soybean was initially opposed by Monsanto until the latter acquired the claiming firm. After the acquisition, Monsanto fully supported the application that was initially opposing (Howard 2015). The link between IPRs and M&A in the seed industry has been empirically verified (Graff et al. 2003, Marco and Rausser 2008).

Concerns have been raised that the high level of concentration in the industry is perhaps the result of strategic planning that aims to *extend intellectual property rights beyond their legitimate bounds in an effort to limit competition* (Moss 2013 p. 549). As argued in Lianos et al. (2016 p. 63), Life Science Multinational Corporations develop IPRs strategies *in order to reinforce their dominance towards farmers, capturing the significant part of the value added along the whole food pipeline*. A protected trait that could be applied to several varieties or even crops can enable a company to gain control of several markets, particularly if the said company has a large legal capacity. This has been the case for large multinational corporations with a global presence. Thus, market power generated by IPRs can be strategically designed in order to limit or control competition, thereby increasing the concentration in the seed industry (Louwaars et al. 2009, Moss 2013). Additionally, IPRs-related policy changes have reduced the enforcement of anti-trust laws, increased the *enforcement of alleged intellectual property infringements* (Howard 2015 p.1) and broadened the scope of protection, all of which has allowed leading firms to increase their power and influence. The combined effect of market deregulation policies and the widespread adoption of IPRs has spurred waves of M&A (Clancy and Moschini 2017, Clapp 2018).

The extensive adoption of IPRs was brought about by the Trade-Related Intellectual Property Rights Agreement (Prifti 2015). According to article 27.1 of the agreement, all products and processes in all fields of technology should be patentable. This means that countries that are members of the World Trade Organization have practically established a patent rights system. The international extension of IPRs during the 1990s was a tool to help governments encourage private sector investment such as R&D in agricultural products. However, it had a profound impact on the access to genetic resources. With every merger and acquisition, firms not only increased their market share, but also their access to genetic material stock and breeding tools, the use of which could be prohibited due to IPRs (Howard 2015).

Results

Consolidation in the global seed markets

Concentration is a common phenomenon in all segments of global food value chains; in the agricultural inputs markets (Howard 2009), agricultural production (MacDonald 2015), industrial processing (MacDonald and McBride 2009) and wholesale/retail distribution (Sexton and Xia 2018). One estimate of the size of the global food and beverages retail market in 2012 was USD 5.98 trillion. In the same period the commercial seed market was reported to have reached USD 47 billion, making the seed sector contribution less than 1% to the global food and beverages retail value chain (Bonny 2014). However, despite the relatively small size of the seed sector, seeds play a significant role in crop production, food security and biodiversity. Thus, the level of consolidation may have paramount consequences.

M&A have played a key role in the evolution of the seed industry worldwide (Srinivasan 2003, Moretti and Matringe 2006, Howard 2009, Fuglie et al. 2011, Pardey et al. 2013, Bonny 2014, 2017, Howard 2015, Lianos et al. 2016). The trend started in the United States in the 1960s and 1970s when the high sales of hybrid seeds, mainly corn, attracted the attention of several chemical, oil and grain trading companies and entered the industry through synergies with seed companies. During 1980s the increased regulations and subsequent loss of profitability combined with aspirations for the potential applications of biotechnology, led pesticide and agrochemical companies to acquire seed companies and invest in newer technologies (Schenkelaars et al. 2011, Howard 2015). In the 1990s, IPRs drove another wave of M&A. Major actors in biotechnology and pharmaceutical sectors acquired seed companies and formed Life Science conglomerates. As agrochemical companies acquired smaller seed companies, they also merged with each other, resulting in fewer and fewer actors globally. In the early 2000s, *the Big Six* large multinational corporations were in place (BASF, Bayer, Dow, DuPont, Monsanto, Syngenta). These are leading companies in the plant biotechnology and agrichemical business, with the exception of Bayer, which primarily remained a pharmaceutical company. In 2016, DuPont and Dow announced that their respective boards of directors had agreed that the companies would merge as equals and form DowDuPont (Dow Corporate 2016). Monsanto's shareholders also approved a proposed merger with Bayer (Bayer 2016). These mergers took place in 2017 and 2018 respectively, reducing the *big six* to the *big four*.

Consolidation in Sweden: 130 years of M&A

Plant breeding in Sweden has a long history of successful operations for over 130 years. The sector contributed significantly to Swedish exports and consequently to GDP. For example, in the mid-1990s, Svalöf AB had approximately 50% of the Canadian market in breeding and marketing varieties of spring oil seed crops (Kuylenstjerna 1997). Yet today, breeding is a significantly less attractive industry. This section presents the changes that took place in the domestic market, primarily with regard to M&A. Supplemental Figure illustrates the major changes.

During the late 19th century, the Swedish Seed Association (SUF) and W. Weibull were established and focused on cereals and fodder and tuber crops, respectively. The market- dominating sugar refinery company Svenska Sockerfabriks AB (SSA) was formed in 1907 by a group of sugar beet producers and refineries to breed sugar beet (Kraft 2010). Agricultural crops were bred by Algot Holmberg and Söner AB, AB Carl Engström and Otto J. Olsson, mainly during the 1920s. The breeding of vegetable crops primarily emerged during the 1930s and 1940s and was conducted by J.E. Ohlsens Enke, L. Daehnfeldts fröhandel and Statens Trädgårdsforsök (Solberg et al. 2016). In 1936, the Förening för växtförädling av skogsträd (Association for Breeding of Forest Trees) was established with facilities at Ekebo and Svalöf and in 1941 Förening för växtförädling av frukt och bär (Association for Breeding of Fruits and Berries) was established. Although the origins of Findus can be traced back to 1905, it was not until the 1980s that the company started breeding peas (Stegmark 2010).

The history of SW Seed accounts for one half of the history of the Swedish breeding sector. SW Seed was the outcome of a merger between two of the most prominent breeding organizations: Svalöf AB and W. Weibull. In 1886 the Allmänna Svenska Utsädesföreningen (ASUF) was established in Svalöf and led by landowners and academics with strong ties to the Alnarp Agricultural Institute and Lund University. This was the beginning of the formation of a strong scientific cluster in Southern Sweden, Svalöf-Landskrona, which expanded both in size and operations in the coming decades (Nilsson and von Bothmer 2010). The main purpose of the association was to trial local and imported varieties in order to determine their value, as well as improve the quality of cereals. Over the years, the association founded several subsidiaries throughout Sweden.

In 1888, Mellersta Sveriges Utsädesförening (MSU) was established with the primary task of conducting field trials. However, it was not financially optimal for both associations to operate so in 1894 they merged and became Sveriges Utsädesförening (SUF). In the following decades, SUF grew in terms of both its facilities and breeding activities, driven by private donations and government funding. In 1891, Allmänna Svenska Utsdädesaktiebolag (ASU) was formed with the aim of supporting, marketing and selling varieties developed by SUF. A major organizational reform took place in 1912 when, in accordance with a government investigation, SUF became a state-subsidized institution. One decade later, the acquisition of Svenska Lantmännens Utsädesaktibolag (SLNU), led to subsequent acquisitions of subsidiaries, a trend that had already started as early as 1907, when ASU increased in size by acquiring properties in several locations. By 1925, Svalöf's varieties would account for up to 25% of the German market for grain crops. The varieties were already present in Denmark, Norway, The Netherlands, France, England and Canada. Several acquisitions took place during 1960s before Lantmännen took over the commercialization of seed from ASU. In 1980, ASU and SUF merged and formed Svalöf AB, the ownership of which was split 50/50 between the state and Lantmännen.

Before the establishment of SUF, the family business W. Weibull began experimenting in breeding fodder crops with the aim of improving foreign varieties to fit Nordic climate conditions. In 1870, the Weibull family farm was able to sell its surplus seed to neighbouring farms (Fajersson 1997). Ten years later the company was exporting seeds to The Netherlands, Hungary and Denmark. Government subsidies also played a decisive role in the history of Weibull as the company would not have been able to survive the post WW1 crisis of the 1920s or the recession of the 1930s without state support. In the late 1940s, Weibull initiated a proposal according to which government subsidies would be replaced by a license system requiring users of the varieties to pay royalties.

It took 20 years before the proposition relating to PBR was passed by the Swedish Parliament. M&A were also a major part of Weibull's history: in 1966 the company acquired one of the oldest seed and plant breeding companies, Algot Holmberg & Söner AB (Gertsson et al. 2010). During the 1970s, W. Weibull was ready to expand, both domestically and internationally. Towards this end, in 1966, Weikalb was established with joint ownership split between Weibull, the French company Florimond Desprez and the American company DeKalb. In 1980, Weibull was acquired by Cardo and five years later the company underwent an organizational transformation: a division between the agricultural sector, which included plant breeding and the seed sector and the international divisions (Svensson and Weibull 1997). In 1985, W. Weibull was transferred to Hilleshög AB in the newly-built Agri Seeds division. In the following year (1986), Cardo was acquired by the Volvo Group, making Weibull part of the Provendors Group. When Sandoz acquired Hilleshög AB in 1987, the various companies of Weibull were reunited. Eventually, in 1993, the Federation of Agricultural Cooperatives (SL) bought out W. Weibull AB and merged with Svalöf AB, creating Svalöf Weibull AB with Lantmännen as the main shareholder. At the time of the merger, the two former companies jointly owned 17 subsidiary companies (three in Sweden, two in Germany, five in Canada, Spain, Argentina, France, United Kingdom, The Netherlands, Italy and Denmark). In 1999, SW Seed and BASF jointly established a new company called BASF Plant Science for the development of plant biotechnology activities. A year later, 14 subsidiary companies remained. By the end of 2003, divestments had occurred in Denmark, Argentina and, by 2006, in the UK, France, Spain and Canada. The collaboration with BASF was dissolved in 2008 when Lantmännen regained full ownership of SW Seed (Nilsson and von Bothmer 2010). In 2009, a new organization, SW Oilseed AB was formed, in which Lantmännen was the major shareholder. In 2011, SW Seed became fully integrated into Lantmännens Lantbruks operations. Divestments continued in 2014 in Germany and Poland. Domestically, in the same year, Secobra acquired SW Seed's spring barley programme. Today, only three breeding stations remain, two in Sweden and one in The Netherlands.

The other half of the history of the Swedish seed industry began in 1907 with the establishment of SSA. At the time, the production of sugar beets was dependent on German varieties. Yet, by the end of 1928, varieties developed at Hilleshög were used exclusively in Sweden and efforts started to expand into other regions in Europe. Towards this end, N.V. Hollandsch-Zweedsche Zaadmaatschappij (HZZ) was established in Amsterdam in 1926 with the primary task of reproducing and selling varieties developed in Hilleshög. During the 1930s, the company responded to the international demand for its varieties by introducing breeding stations in England, Belgium, The Netherlands and France. During the 1960s, SSA invested successfully in other branches, which led to an organizational transformation. Cardo AB, an investment company, was established in 1968 with SSA as its subsidiary. Several business segments belonging to SSA were transferred to the newly established Hilleshögs Frö AB (later known as Hilleshögs AB), as well as seed companies and subsidiaries in Holland, France and Italy (Bosemark 1997). Scientific breakthroughs, including the development of monogerm sugar beet seed, tripled foreign sales from 1972 to 1974, which resulted in the acquisition of and investment in several foreign seed companies. By the end of the 1970s, Hilleshög had a leading position in several markets including France, Germany, Holland, England, Italy, the USA and Japan. When Cardo AB took over W. Weibull AB, Hilleshög AB expanded its breeding activities to include breeding programmes in grains, rapeseed and forest trees. In the early 1980s, Cardo AB's directors decided that it would be mutually beneficial for both Cardo AB and Hilleshög AB for the latter to gain autonomy. In 1985, Hilleshög AB acquired W. Weibull AB from Cardo AB, and a few months later Volvo acquired Cardo AB, thereby also acquired Hilleshögs AB. The new owner strengthened sugar beet operations by taking over breeding stations and sugar beet seed companies in France, Belgium and the USA and the breeding of rapeseed was intensified. In 1989, Hilleshög AB was acquired by the Swiss company Sandoz AG when the former held a 30% market share for sugar beets in Western Europe, making Sandoz Seeds the world's largest seed company. In 1992, there was yet another organizational transformation: Hilleshög AB, including all its subsidiary companies, merged with the Northrup-King Seed Company, forming Hilleshög NK. Hilleshög AB was now a subsidiary of Hilleshög NK. Despite the organizational changes, Landskrona was still the centre of sugar beet plant breeding. In 1996, Santzoz AG merged with Ciba Geigy AG, forming Novartis AB. The following year, Hilleshög AB was renamed Novartis Seeds AB. When Novartis Agribusiness merged with Zeneca Agrichemicals Syngenta was established and Swedish operations remained under the name of Syngenta Seeds AB. Since 2010, Syngenta has acquired numerous smaller companies and merged with larger ones (Howard 2009). From a Swedish perspective since 2010, the most noticeable one was the acquisition of Lantmännen's winter wheat and winter oilseed rape operations in Germany and Poland (Syngenta 2014). In 2016, one third of its employees in Landskrona were laid off. The following year, after Syngenta´s acquisition by ChemChina, the later decided to sell off the sugar breeding programme to the Danish DLF. A new subsidiary company of DLF has since emerged: MariboHilleshög was established in October 2017 and the "former Hilleshög site in Landskrona, Sweden, is the base for R&D activities in MariboHilleshög and is named MariboHilleshög Research AB" (MariboHilleshög 2019).

The family business of Otto J. Olson & Son AB was established in 1925, focusing on root crops, forages and oil plants (Olsson 1997). By 1927, the company was already marketing its own varieties. In the 1930s, the firm expanded, primarily through the acquisition of adjacent properties. After the acquisition from ASU in 1961, the company was renamed AB Hammenhögs Frö and continued breeding activities in collaboration with ASU in Hammenhög until 1971, when SUF took over. In the same year ASU acquired the Swedish subsidiary company Ohlens Enke AB, whose operations were transferred to Hammenhög. A few years later, ASU also acquired the Danish parent company Ohles Enke A/S. By the time Svalöf was established, both Otto J. Olson and Ohles Enke belonged to Svalöf AB.

Algot Holmberg & Söner AB was established in 1927. By the late 1890s it was already involved in production and seed sales with a focus on fodder beets and legumes and had formed a successful collaboration with the Danish cooperative Pajbjergfonden, which lasted for 40 years (Elovson 1997). Findus couldn't avoid being taken over, either. In 2015 the company was acquired by Nomad Foods, which has its headquarters in the UK. A few months later, Findus' CEO, announced the closure of the production plant in Malmö, with the simultaneous termination of plant breeding and pea cultivation by the end of March 2017 (Kolmodin 2017). However, in 2018, the company signed a 25-year leasing agreement with Bjuv municipality, ensuring continuation of the plant breeding programme for peas (Malm 2018).

Swedish cultivars; the extent of dependence on foreign-bred varieties

We provide an assessment of the impact of the structural changes that have taken place in the Swedish seed industry as follows: First, by reporting the number of new registrations in the Swedish Plant Variety List (PVL) and new registrations in the Swedish PBR list. Granting IPRs such as PBR ensures that only the owner of the variety rights can reproduce, process, sell, import and export the variety. Thus, it is a broadly used proxy for innovation. However, the availability of a range of new cultivars does not necessarily imply that farmers are opting for such cultivars. Thus, as a next step, we identified the origin of the breeding station for all produced cultivars of certified seed in Sweden for 2014, 2015 and 2016 and then calculated the percentage of the total volume of the produced seed originating from Swedish laboratories.

Figure 2 shows new registrations for agricultural and horticultural crops on the Swedish Plant Varieties List from 1971 to 2016. Figure 3 shows new registrations in the Swedish PBRs list. Both figures show a peak in the approved varieties of 1995 and 1996, followed by a gradual decline. This is not surprising since being tested and listed in Sweden is a common marketing strategy of foreign-bred varieties. Listing a variety in the national catalogue provides useful information to farmers and therefore makes the foreign varieties more appealing. A similar approach was adopted by Solberg and Breian (2015), whereby the authors reported a remarkable decline in the total number of Swedish-bred cultivars: from 261 cultivars in 1952 to 161 in 2013 (Solberg and Breian 2015). However, the authors used the total number – as opposed to new registries – of Swedish-bred varieties listed in distinct time periods. By examining new registries, we reduced time-lag bias since PBRs last for a period of 20 years. It should be noted that the graphs include new registration in both domestic and foreign bred varieties. Therefore as a next step, we examine the ratio of domestic to foreign varieties certified in Sweden during the period 2014–2016 (Fig. 4).

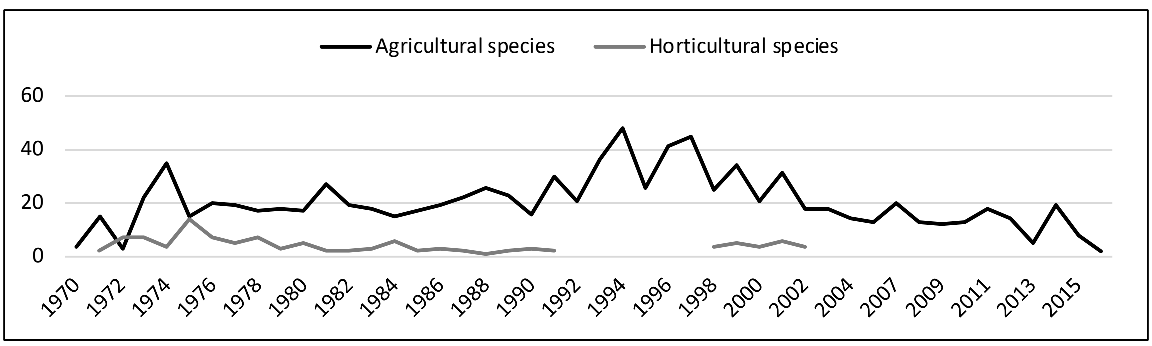

Fig. 2. Registrations in the Swedish National List of Plant Varieties 1970–2016

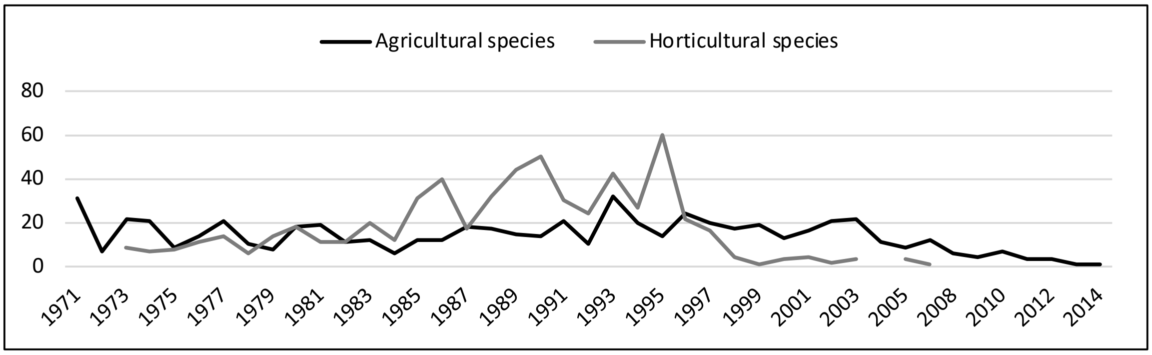

Fig. 3. Annual Plant Variety Protection Grants (PBRs)

Specifically, Figure 4 reports the results for the crops that show variation between Swedish and non-Swedish-bred cultivars based on the class of seed. Classes F, A and B correspond to nucleus, pre-basic and foundation seed and classes C, C1, C2, and C3 to certified seed. Wheat and oats are the two crops with a relatively high presence of Swedish-bred cultivars. There is still a limited amount of Swedish bred-varieties on the market for winter rye, although rye breeding stopped in 2006. In contrast, we found that for the remaining cereal crops, almost all winter barley, spelt, spring durum wheat, spring triticale and maze cultivars were not bred in Sweden. Nor are there any Swedish-bred cultivars for oil and fibre plants such as seed flax, soybean, hemp, caraway or sunflower.

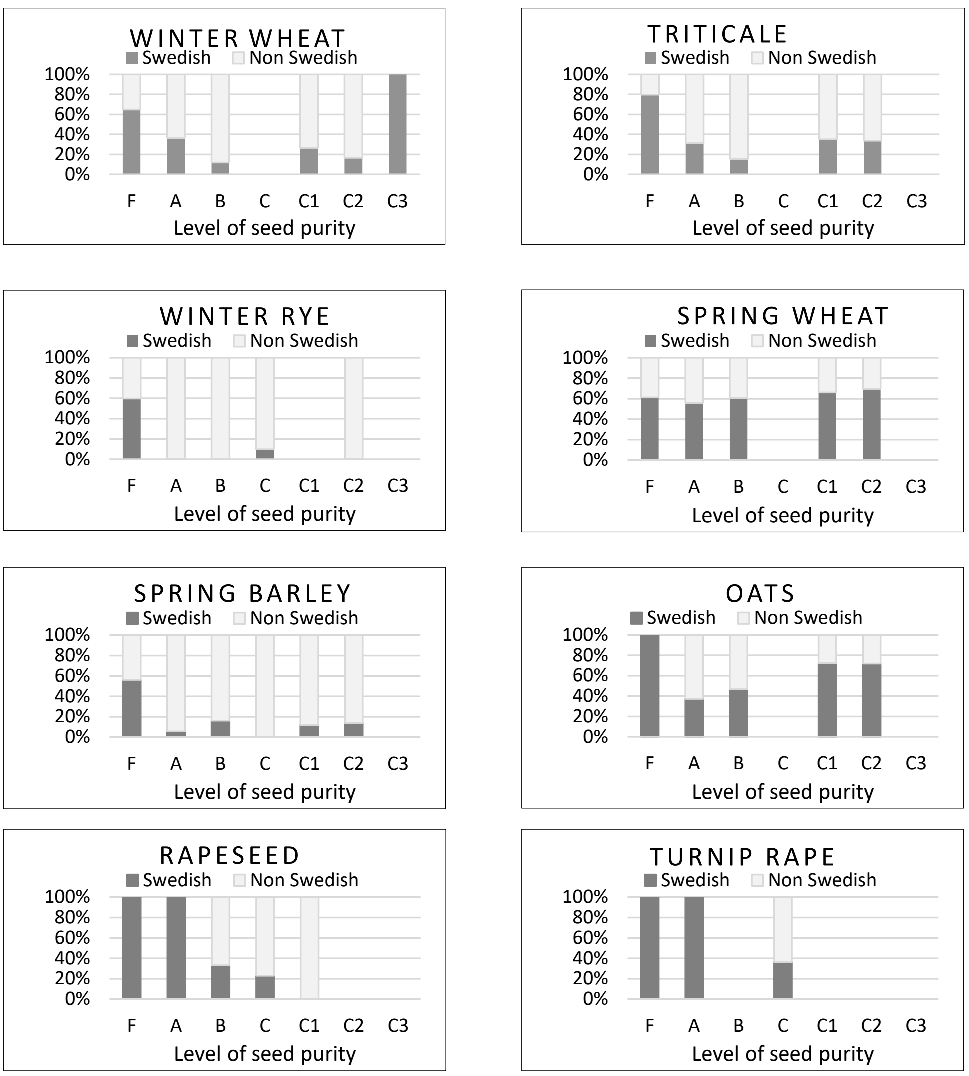

Fig. 4. Percentage of the volume of the production of certified seed from 2013–2015 that corresponds to Swedish-bred cultivars. Note: The level of seed purity decreases along the various classes; starting from class F that corresponds to nucleus seed to class C3, which corresponds to certified seed of 3rd generation of multiplications.

Note that the average of the years 2013–2015 has been calculated in order to reduce potential bias for annual variability. As is evident from the figures, the production volume of Swedish- bred cultivars is highly crop and class specific. Plant breeding is a time demanding process – up to 15 years – which implies that a reduction in efforts in the near past or in the present will be evident in the future.

Recent developments in Sweden

Certain initiatives have been taken by private actors, the state or public-private partnerships (PPP) aimed at facilitating and strengthening plant breeding in Sweden. One example of the latter was a proposal in 2010 by the Nordic Council of Ministers for the establishment of a PPP for pre-breeding. Several plant breeding and pre-breeding projects were developed in a collaboration between breeding companies and universities with funding split 50/50 between public sector sources and the industry. As stated by Nilsson et al. (2016 p. 9) *the growing awareness in society of the consequences of increased dependency on seeds from large multinational breeding companies* resulted in the formation of this PPP.

Another example is the agreement between the Swedish Seed Trade Association (SVUF), the Federation of Swedish Farmers (LRF) and the Swedish Board of Agriculture (SBA) concerning the fees for the use of farm-saved seed of protected varieties by PBRs. The parties renewed the contract in 2015, including a stipulation according to which farmers who fail to declare their use of FSS will face a penalty fee based on their total farm acreage. According to SVUF representative, the association was able to implement this regulation due to *the value and importance the farmers' organizations are placing on dedicated variety development for the diverse growing conditions in our long and narrow country* (Henriksson, P. personal communication November 2016). This "compulsory acreage fee" is a unique arrangement both in Europe and globally.

Lastly, the state has recently resumed its support of plant breeding in order to facilitate long-term sustainable agriculture in Sweden. In January 2017, the government presented a bill on food safety and food chain sustainability, including plant breeding, as a pillar of this strategy (Government White Paper 2017). The focal point of the bill with respect to plant breeding is the need to make use of new methods and innovations in order to ensure access to local and regional varieties, as well as to contribute to full utilization of production resources and to the adaptation of agriculture to climate change. Later the same year, the SBA published an action plan to tackle climate change (Swedish Board of Agriculture 2017). According to the plan, plant breeding must be taken into account in the development of a sustainable society. Furthermore, the SBA highlighted the need for special capital to accommodate the challenges posed by the unique daylight climate conditions. This led to the announcement of the Budget Bill in 2018 were of 90 million SEK were allocated for the establishment of a competence centre of plant breeding at the Swedish University of Agricultural Sciences (SLU) within a three-year period (Government Offices of Sweden 2017).

Discussion

The Swedish plant breeding and seed production industry due to scientific breakthroughs such as the development of monogerm sugar beet seed had dynamic start, which was then followed by several waves of M&A. The industry was unable to retain its leading position on the global market. The current domestic production of certified seed is highly dependent on varieties bred in non-Swedish facilities. The establishment and enforcement of IPRs has been a major driving force behind this development. Other reasons include changes in domestic agricultural policy, as well as Sweden's accession to the EU.

The increased demand for intellectual property protection was a consequence of the advent of biotechnological innovation in agriculture. Since the beginning of agriculture, farmers have been producing and saving seeds. They would use mass selection in order to improve the yield or quality of the next season's harvest. However, hybridization, a breeding technique that provides protection against seed savings, paved the way for controlling plant genetic material and reproductive capacities (Kotschi and Horneburg 2018, Muzaka 2018). Since hybrids lose their vigour after one generation, farmers turned to outside the farm sources for seed, thus became increasingly dependent on external seeds. At the same time, parent lines of hybrid varieties could also be subject to property protection (Kloppenburg 2005). As the demand for private seed systems grew, so did the demand for the protection of breeding techniques and the developed varieties (Muzaka 2018). For crops that hybridization was not achieved, meaning absence of technical protection against seed savings embedded in the seed, IPRs secured proprietary control over germplasm and developed varieties (Kloppenburg 2005).

IPRs, nonetheless, create power asymmetry in the food value chain. Holding IPRs for materials such as genes, germplasm or breeding tools essential to the development of new products can generate “patent thickets”; a situation that occurs when overlapping set of patents block commercialization of new technologies (Shapiro 2000, Srinivasan 2003). Theoretically, if a plant breeder has the ability to “design” around a given patent, the power that the patent holder can assert is relatively limited (Shapiro 2000). However, in industries such as plant biotechnology, which have multiple overlapping patents, some of them already issued while others are still pending, the risk of patent infringement is severe. Some companies may refrain from introducing new products because of the fear of a holdup problem (Shapiro 2000, Maisashvili et al. 2016). Thus, firms that are able to control intangible assets such as IPRs can set barriers to competition (Vorley 2001). Cross licensing or patent pools are two market-based solutions to this problem. However, taking into account the high transaction costs, the aggregation of IPRs through M&A has proven to be a more efficient approach (Clancy and Moschini 2017).

M&A derived from the need to control relevant IPRs took place in Sweden. Specifically, the dependence on contractual licensing agreements had a profound impact on the decisions taken by SW Seed’s management. According to a former research director at Svalöf Weibull AB, for almost two decades, SW Seed, as a medium-sized company with international ambitions, found itself exposed to and dependent on licensing agreements (personal communication November 2016). In order to mitigate the impact of this adverse reality, the management team decided to form a partnership with a major multinational corporation that would, however, allow the organization to maintain its independence while providing it with access to patents. This aspiration would be realized through a collaboration with BASF which, at the time (mid 1990s), was trying to establish itself as one of the last major players in plant biotechnology. Despite their best efforts, the partnership did not generate the anticipated results.

Time delays in the development of genetically modified varieties on the part of BASF and some failed attempts in breeding programmes on the part of SW led to a change in attitude within Lantmännen’s management regarding the strategic value of plant breeding – followed by years of gradual disinvestment. In recent years, acquisition of the breeding station in Germany by Syngenta and the collaboration with Secobra in 2014 were realized as a means of enabling Lantmännen to access material and technologies protected by IPRs and owned by Syngenta and Secobra (Gertsson et al. 2014).

M&A and the subsequent dependence on foreign-bred varieties were also brought about by changes in domestic agricultural policy. At the beginning of the 20th century, it was broadly accepted that the public sector was best suited to conducting breeding activities due to the nature of the process and the outcome. Breeding is a time-consuming process associated with basic and fundamental research and the welfare effects generated by the development of new varieties are split across society, rather than specific groups (Helgadottir 2014). Thus, government institutions allocated the necessary resources to the cultivation of new varieties. An example of such state support was the establishment of SUF which, in practice, has been a semi-public sector research institute, with breeding programmes targeting both marginalized crops and regions. For many decades, it was often requesting for breeding organizations in Svalöf to be unified by gradually integrating all breeders into one organization. However, this request was only realized in 1980. One of the biggest issues to overcome at the time was the extent of financial support from the state. Farmers demanded the continuation of state involvement in breeding while the state, to some extent, was planning to reduce its involvement (Kuylenstjerna 1997). Eventually an agreement was reached: the state would continue to fund crops whose breeding was deemed unprofitable. This was a transitional period for breeding in Sweden. Svalöf had the twin objective of being profitable while also continuing to breed marginalized but socially valuable crops. At the end of the 1980s, the political climate changed. The state decided to reduce land allocated for agricultural production and cease supporting costly programmes. At the time of the Svalöf-Weibull merger, the state withdrew from Svalöf and plant breeding in Sweden was reduced by 25% (Kuylenstjerna 1997).

Recently, the lack of public support and subsequent dependence of Swedish breeders on MLC was raised by the chairperson of the board of Lantmännen. When commenting on recent changes at SW Seed, he stated that the private sector was not in a position to bear the cost of R&D related to breeding on its own and drew attention to the state’s need to resume financial support through university-driven research that could be utilized by private breeders (Åhman et al. 2016).

Another catalyst for the decline was Sweden’s accession to the EU in 1995. Historically, Swedish breeders only developed high-quality varieties. After joining the EU and the concurrent radical changes in the agricultural sector brought about by the application of the Common Agricultural Policy to Swedish agriculture, breeders faced fierce competition from foreign varieties (Kuylenstjerna 1997). This was because, prior to EU membership, foreign varieties had to be registered on the Swedish PVL. The Swedish Plant Variety Office had been able to maintain strict quality requirements for new varieties. After 1995, varieties from other EU countries could be marketed directly in Sweden without any requirement to be listed on the national PVL. This decline is evident in Figures 3 and 4. Starting from the 1970s, annual registrations in the Swedish PVL and PRBs lists increased up until 1995. The 1995 pick follows a gradual decline, which has continued until the present day.

This decline can also be understood considering Sweden´s location and climate conditions; a country with small area of arable land – less than 3% of the EU's total utilized agricultural area – and a harsh climate that affects crop production in most parts of the country. This means that the domestic market for inputs in crop production is small. International actors have limited interest in developing varieties that are suited to the Nordic climate, given that R&D costs, combined with the cost of registration and seed multiplication, would exceed revenues (Official Reports of the Swedish Government 2015). Multinational breeding companies focus their research activities on the most profitable crops and crops that are cultivated on a large scale, rather than small markets. Therefore, the gap that was created when the state ceased the support of breeding programs focusing on marginalized areas or crops, was not replaced by the private sector.

Domestic breeding programs nevertheless, generate financial gains in agricultural production. Varieties developed for Northern Germany or Denmark, perform less satisfactorily in the northern parts of the country resulting in productivity losses. According to Lantmännen, the additional added value of domestically-bred varieties from 2009–2014 reached SEK 390 per hectare (Gertsson and Olesen 2016). The annual added value of Swedish bred varieties for cereal, oilseed, fodder and pea crops has been reported to be SEK 400 million (Nilsson and von Bothmer 2010). Furthermore, in countries in which public plant breeding has a significant presence, the average price of seed is lower, which decreases the cost of farm inputs, thereby increasing farmers' profitability (OECD 2018).

Lastly, plant breeding is a valuable and cost-effective tool in Sweden for meeting climate change challenges (Henriksson 2010, Helgadottir 2014, Gertsson and Olesen 2016). An IPCC report has estimated future temperature increases based on three different scenarios. These scenarios have been applied to local climate models in order to predict the direction in which Sweden is heading. The estimates show an increase of 1°C up to 2.5 °C by 2040 (Kjellström et al. 2016). An expansion of the growing season is anticipated, which will increase the diversity of cultivated crops, especially for the north-western parts of the country. However, the decline in rainfall that is also anticipated could pose a threat to the primary sector in Sweden (Swedish Board of Agriculture 2012). Broadening the genetic base of local crop plants could be a way of addressing these concerns and ensuring the competitiveness of the agricultural sector (Helgadottir 2014, Eriksson et al. 2018).

Conclusions

The aim of the article is to map the evolution of plant breeding industry in Sweden and to provide an assessment of the use of cultivars that have been bred domestically over foreign bred cultivars. We find that Sweden lost its leading role in global markets and the ability to control domestic market. A period of expansion and growth was followed by several waves of M&A. The establishment and enforcement of IPRs played a significant role in the evolution of the plant breeding industry in Sweden and internationally as they spurred M&A. An outcome of this development is the high usage of certified seed produced from varieties bred in non-Swedish laboratories. Additionally, it is broadly recognized that breeding companies in Sweden are no longer capable of bearing the considerable cost of plant breeding on their own. The future of plant breeding in Sweden is tied to partnerships with major international actors and to the extent of government financial support.

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References

Bayer 2016. Monsanto Shareowners Approve Merger with Bayer. 13 September. http://www.press.bayer.com/baynews/baynews.nsf/id/Monsanto-Shareowners-Approve- Merger-with-Bayer

Berg, B.L. 2001. Qualitative Research Methods for the Social Sciences. Boston: Allyn and Bacon. 328 p.

Blakeney, M. 2011. Trends in intellectual property rights relating to genetic resources for food and agriculture. Background study paper 58. http://www.fao.org/3/mb684e/mb684e.pdf

Bonny, S. 2014. Taking stock of the genetically modified seed sector worldwide: market, stakeholders, and prices. Food Security 6: 525–540. https://doi.org/10.1007/s12571-014-0357-1

Bonny, S. 2017. Corporate concentration and technological change in the global seed industry. Sustainability 9 (1632): 1–25. https://doi.org/10.3390/su9091632

Bosemark, N.O. 1997. Hilleshög AB. In: Olsson, G. (ed.). Den Svenska Växtförädlingens Historia: Jordbruksväxternas Utveckling Sedan 1880-Talet. Stockholm: Kungl. Skogs- och lantbruksakad. p. 63–76. (in Swedish).

Bosona, T. & Gebresenbet, G. 2013. Food traceability as an integral part of logistics management in food and agricultural supply chain. Food control 33: 32–48. https://doi.org/10.1016/j.foodcont.2013.02.004

Cho, J. & Lee, E.H. 2014. Reducing Confusion about Grounded Theory and Qualitative Content Analysis: Similarities and Differences. The Qualitative Report 19: 1–20.

Clancy, M. & Moschini, G. 2017. Intellectual Property Rights and the Ascent of Proprietary Innovation in Agriculture. Annual Review of Resource Economic 9: 53–74. https://doi.org/10.1146/annurev-resource-100516-053524

Clapp, J. 2018. Mega-Mergers on the Menu: Corporate Concentration and the Politics of Sustainability in the Global Food System. Global Environmental Politics 18: 12–33. https://doi.org/10.1162/glep_a_00454

Dallas, M.P., Ponte, S. & Sturgeon, T.J. 2019. Power in global value chains. Review of International Political Economy 26: 666–694. https://doi.org/10.1080/09692290.2019.1608284

Dow Corporate 2016. DuPont and Dow Announce Senior Leadership Appointments. 23 May 2016. https://corporate.dow.com/en-us/news/press-releases/dow-and-dupont-announce-senior-

Elovson, R. 1997. Algot Holmberg & Söner AB, In: Olsson, G. (ed.). Den Svenska Växtförädlingens Historia: Jordbruksväxternas Utveckling Sedan 1880-Talet. Stockholm: Kungl. Skogs- och lantbruksakad. p. 81–84 . (in Swedish).

Eriksson, D., Brinch-Pedersen, H., Chawade, A., Holme, I.B., Hvoslef-Eide, T.A., Ritala, A., Teeri, T.H. & Thorstensen, T. 2018. Scandinavian perspectives on plant gene technology: applications, policies and progress. Physiologia plantarum 162: 219–238. https://doi.org/10.1111/ppl.12661

Eriksson, M., Nathalie, P. & Ranjan, G. 2016. Food chain sustainability in Sweden. Report 168, Uppsala: SLU Department of Economics. http://pub.epsilon.slu.se/13495/

Fajersson, F. 1997. Weibullsholm; Familjeföretagets utveckling 1870-1980. In: Olsson, G. (ed.). Den Svenska Växtförädlingens Historia: Jordbruksväxternas Utveckling Sedan 1880-Talet. Stockholm: Kungl. Skogs- och lantbruksakad. p. 35–50. (in Swedish).

FAO 2018. Transforming food and agriculture to achieve the SDGs: 20 interconnected actions to guide decision-makers. In: Sustainable Development Goals. Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/3/I9900EN/i9900en.pdf

Fuglie, K., Heisey, P., King, J.L., Day-Rubenstein, K., Schimmelpfennig, D. & Wang, S.L. 2011. Research Investments and Market Structure in the Food Processing, Agricultural Input, and Biofuel Industries Worldwide. USDA-ERS Economic Research Report 130. https://doi.org/10.2139/ssrn.2027051

Gelli, A., Hawkes, C., Donovan, J., Harris, J., Allen, S.L. & de Brauw, A. 2015. Value Chains and Nutrition: A Framework to Support the Identification, Design, and Evaluation of Interventions. Social Science Research Network, Rochester, NY. https://doi.org/10.2139/ssrn.2564541

Gereffi, G., Humphrey, J. & Sturgeon, T. 2005. The governance of global value chains. Review of international political economy 12: 78–104. https://doi.org/10.1080/09692290500049805

Gereffi, G. & Lee, J. 2012. Why the world suddenly cares about global supply chains. Journal of supply chain management 48: 24–32. https://doi.org/10.1111/j.1745-493X.2012.03271.x

Gereffi, G., Lee, J. & Christian, M. 2009. US-based food and agricultural value chains and their relevance to healthy diets. Journal of hunger & environmental nutrition 4: 357–374. https://doi.org/10.1080/19320240903321276

Gertsson, B. & Olesen, A. 2016. Swedish Plant Breeding for a Competitive Agriculture. Sveriges Utsädesförening Tidskrift 125: 67–74. (in Swedish).

Gertsson, B., Börjesdotter, D. & Olesen, A. 2010. From field to fork - the chain starts with Lantmännen SW Seed. Sveriges Utsädesförening Tidskrift 117: 21–25. (in Swedish).

Gertsson, B., Olesen, A. & Annas, P. 2014. The plant breeding activities of Lantmännen. Sveriges Utsädesförening Tidskrift 123: 27–32. (in Swedish).

Government Offices of Sweden 2017. Nya växtsorter för ett förändrat klimat. Näringsdepartementet. https://www.regeringen.se/pressmeddelanden/2017/09/nya-vaxtsorter-for-ett-forandrat-klimat/. (in Swedish).

Government Offices of Sweden 2018. The agricultural sector and the drought. Näringsdepartementet. https://www.government.se/articles/2018/08/the-agricultural-sector-and-the-drought/

Government White Paper 2017. En livsmedelsstrategi för Sverige – fler jobb och hållbar tillväxt i hela landet. Prop. 2016/17:104. (in Swedish).

Graff, G.D., Rausser, G.C. & Small, A.A. 2003. Agricultural biotechnology's complementary intellectual assets. Review of economics and statistics 85: 349–363. https://doi.org/10.1162/003465303765299864

Gullstrand, J. & Jörgensen, C. 2012. Local price competition: The case of Swedish food retailers. Journal of Agricultural & Food Industrial Organization 10: 1–27. https://doi.org/10.1515/1542-0485.1365

Helgadottir, A. 2014. Why is public plant breedign importnat in the Nordic region? Sveriges Utsädesförening Tidskrift 123: 23–27. (in Swedish).

Hendrickson, M., Howard, P.H. & Constance, D. 2019. Power, Food, and Agriculture: Implications for Farmers, Consumers, and Communities. In: Hansen, J., Gibson, J. & Alexander, S. (eds.). Defense of Farmers: The Future of Agriculture in the Shadow of Corporate Power. Lincoln: University of Nebraska Press. p. 13–62. https://doi.org/10.2307/j.ctvgs0crb.7

Henriksson, P. 2010. Future Demands for Development of Varieties for the Swedish Market: How can we ensure continued plant breeding efforts of Swedish crops production? Sveriges Utsädesförening Tidskrift 117: 40–43. (in Swedish).

Howard, P.H. 2009. Visualizing Consolidation in the Global Seed Industry: 1996-2008. Sustainability 1: 1266–1287. https://doi.org/10.3390/su1041266

Howard, P.H. 2015. Intellectual Property and Consolidation in the Seed Industry. Crop Science 55: 2489–2495. https://doi.org/10.2135/cropsci2014.09.0669

Humphrey, J. & Memedovic, O. 2006. Global value chains in the agrifood sector. United Nations Industrial Development Organization Working Paper, Vienna, 2006. https://www.unido.org/sites/default/files/2009-05/Global_value_chains_in_the_agrifood_sector_0.pdf

IPCC 2018. Global Warming of 1.5 °C. The Intergovernmental Panel on Climate Change. https://www.ipcc.ch/sr15/

Kalaitzandonakes, N. & Bjornson, B. 1997. Vertical and horizontal coordination in the agro-biotechnology industry: Evidence and implications. Journal of Agricultural and Applied Economics 29: 129–13. https://doi.org/10.1017/S1074070800029187

Kjellström, E., Bärring, L., Nikulin, G., Nilsson, C., Persson, G. & Strandberg, G. 2016. Production and use of regional climate model projections - A Swedish perspective on building climate services. Climate services 2: 15–29. https://doi.org/10.1016/j.cliser.2016.06.004

Kloppenburg, J.R. 2005. First the seed: The political economy of plant biotechnology. Univ of Wisconsin Press. 468 p.

Kolmodin, L. 2017. Nu är Findus historia i Bjuv. Sydsvenskan. 2 April 2017. https://www.sydsvenskan.se/2017-04-02/nu-ar-findus-historia-i-bjuv. (in Swedish).

Kotschi, J. & Horneburg, B. 2018. The Open Source Seed Licence: A novel approach to safeguarding access to plant germplasm. PLOS Biology 16: 3000023. https://doi.org/10.1371/journal.pbio.3000023

Kraft, T. 2010. Syngenta. Sveriges Utsädesförening Tidskrift 117: 26–31. (in Swedish).

Kuylenstjerna, G. 1997. Svalöf AB och Svalöf Weibull AB. In: Olsson, G. (ed.). Den Svenska Växtförädlingens Historia : Jordbruksväxternas Utveckling Sedan 1880-Talet. Stockholm: Kungl. Skogs- och lantbruksakad. p.53–62. (in Swedish).

Lee, J. & Gereffi, G. 2015. Global value chains, rising power firms and economic and social upgrading. Critical perspectives on international business 11: 319–339. https://doi.org/10.1108/cpoib-03-2014-0018

Lesser, W. 1999. Intellectual property rights and concentration in agricultural biotechnology. AgBioForum 1: 56–61.

Lianos, I., Katalevsky, D. & Ivanov, A. 2016. The Global Seed Market, Competition Law and Intellectual Property Rights: Untying the Gordian Knot. Concurrences 2: 62–80. https://doi.org/10.2139/ssrn.2773422

Louwaars, N., Dons, H., Overwalle, V., Raven, H., Arundel, A., Eaton, D. & Nelis, A. 2009. Breeding Business. The Future of Plant Breeding in the Light of Developments in Patent Rights and Plant Breeder's Rights. CGN Report 2009-14, Wageningen: Centre for Genetic Resources. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1720088

MacDonald, J.M. 2015. Trends in agricultural contracts. Choices 30: 1–6.

MacDonald, J.M. & McBride, W.D. 2009. The transformation of US livestock agriculture scale, efficiency, and risks. Economic Information Bulletin No EIB 43. Washington, DC, USA: USDA Economic Research Service. https://doi.org/10.2139/ssrn.1354028

Maisashvili, A., Bryant, H., Raulston, J.M., Knapek, G., Outlaw, J. & Richardson, J. 2016. Seed prices, proposed mergers and acquisitions among biotech firms. Choices 31: 1–11.

Malm, C. 2018. Findus växtförädling stannar i Bjuv genom avtal med kommunen. Svenska Livsmedelsnyheter. 4 September. https://www.livsmedelsnyheter.se/findus-vaxtforadling-stannar-i- bjuv-genom-avtal-med-kommunen-2/. (in Swedish).

Marco, A.C. & Rausser, G.C. 2008. The role of patent rights in mergers: Consolidation in plant biotechnology. American Journal of Agricultural Economics 90: 133–151. https://doi.org/10.1111/j.1467-8276.2007.01046.x

MariboHilleshög 2019. Maribohilleshög ApS. https://maribohilleshog.com/who-we-are/

Moretti, I.M. & Matringe, O. 2006. Tracking the trend towards market concentration: The case of the agricultural input industry. In: United Nations Conference on Trade and Development: Geneva, Switzerland. 60 p. https://www.grain.org/en/article/2197-unctad-study-tracking-the-trend-towards-market-concentration-the-case-of-the-agricultural-input-industry

Moss, D.L. 2013. Competition, intellectual property rights, and transgenic seed. South Dakota Law Review 58: 543–559.

Muzaka, V. 2018. Intellectual Property for Pharmaceuticals and Plant Genetic Resources in Historical Perspective. In: Food, Health and the Knowledge Economy. Springer. p. 63–87. https://doi.org/10.1057/978-1-137-59306-1_4

Nilsson, A. & von Bothmer, R. 2010. Is there a future for public plant breeding in Sweden? Sveriges Utsädesförening Tidskrift 117:34–39.

Nilsson, A., von Bothmer, R., Johanesson, T. & Nybom, H. 2016. Promoting Nordic Plant Breeding for the Future: PPP Public Private Partnership for Pre-breeding. Nordic Council of Ministers. ANP 2016:730. Copenhagen. 27 p. https://doi.org/10.6027/ANP2016-730

Nilsson, M. 2007. The In- and Out-Licensing of Plant Varieties. In: Krattiger, A., Mahoney, R., Nelsen, L., Thomson, J., Bennett, A. & Mahoney, R. (eds.). Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices. Oxford: Centre for Management of Intellectual Property in Health Care and Development. p. 1017–1027.

OECD 2018. Concentration in Seed Markets: Potential Effects and Policy Responses. Paris: OECD Publishing. https://doi.org/10.1787/9789264308367-en

Oehmke, J.F. & Wolf, C.A. 2003. Measuring concentration in the biotechnology R&D industry: adjusting for interfirm transfer of genetic materials. AgBioForum 6: 134–140

Official Reports of the Swedish Government 2015. Attraktiv, innovativ och hållbar - strategi för en konkurrenskraftig jordbruks- och trädgårdsnäring. Näringsdepartementet. SOU 2015:15. (in Swedish).

Olsson, G. 1997. Otto J. Olson & Son i Hammenhög. In: Olsson, G. (ed.). Den Svenska Växtförädlingens Historia: Jordbruksväxternas Utveckling Sedan 1880-Talet. Stockholm: Kungl. Skogs- och lantbruksakad. p. 77–80. (in Swedish).

Pardey, P., Koo, B., Drew, J., Horwich, J. & Nottenburg, C. 2013. The evolving landscape of plant varietal rights in the United States, 1930-2008. Nature Biotechnology 31: 25–29. https://doi.org/10.1038/nbt.2467

Prifti, V. 2015. Intellectual Property in Plant Breeding. In: The Breeder's Exception to Patent Rights, Springer International Publishing. p.31–78. https://doi.org/10.1007/978-3-319-15771-9_4

Schenkelaars, P., de Vriend, H., Kalaitzandonakes, N., Magnier, A. & Miller, D. 2011. Drivers of Consolidation in the Seed Industry and its Consequences for Innovation. Report commissioned by COGEM. https://www.lisconsult.nl/files/docs/consolidation_seed_industry.pdf

Sexton, R.J. & Xia, T. 2018. Increasing Concentration in the Agricultural Supply Chain: Implications for Market Power and Sector Performance. Annual Review of Resource Economics 10: 229–251. https://doi.org/10.1146/annurev-resource-100517-023312

Shapiro, C. 2000. Navigating the patent thicket: Cross licenses, patent pools, and standard setting. Innovation policy and the economy 1: 119–150. https://doi.org/10.1086/ipe.1.25056143

Shi, G. 2009. Bundling and licensing of genes in agricultural biotechnology. American Journal of Agricultural Economics 91: 264–274. https://doi.org/10.1111/j.1467-8276.2008.01174.x

Solberg, S., Diederichsen, A., Helgadottir, A., Dalmannsdottir, S., Djurhuus, R., Frederiksen, A. Poulsen, G. & Yndgaard, F. 2016. Plant Genetic Resources and Climate Change: Stakeholder Perspectives from the Nordic and Arctic Regions. In: Applied Mathematics and Omics to Assess Crop Genetic Resources for Climate Change Adaptive Traits. p.13–24. https://doi.org/10.1201/b19518-4

Solberg, S.O. & Breian, L. 2015. Commercial cultivars and farmers' access to crop diversity: A case study from the Nordic region. Agricultural and Food Science 24:150–163. https://doi.org/10.23986/afsci.48629

Srinivasan, C.S. 2003. Concentration in ownership of plant variety rights: some implications for developing countries. Food Policy 28: 519–546. https://doi.org/10.1016/j.foodpol.2003.10.003

Stegmark, R. 2010. Plant breeding at Findus. Sveriges Utsädesförening Tidskrift 117: 31–33.

Svensson, G. & Weibull, P. 1997. Weibullsholm som en del i olika storföretag 1980-1992. In: Olsson, G. (ed.). Den Svenska Växtförädlingens Historia: Jordbruksväxternas Utveckling Sedan 1880-Talet. Stockholm: Kungl. Skogs- och lantbruksakad. p. 51–53. (in Swedish).

Swedish Board of Agriculture 2012. Vässa växtskyddet för framtidens klimat. Rapport 2012:10. 92 p. (in Swedish).

Swedish Board of Agriculture 2014. Certifiering av utsäde 2013/2014, Fröburna vekstslag. Jönköping, Sweden. 29 p. (in Swedish).

Swedish Board of Agriculture 2015. Certifiering av utsäde 2014/2015, Fröburna vekstslag. Jönköping, Sweden. 32 p. (in Swedish).

Swedish Board of Agriculture 2016. Certifiering av utsäde 2015/2016, Fröburna vekstslag. Jönköping, Sweden. 32 p. (in Swedish).

Swedish Board of Agriculture 2017. Handlingsplan för klimatanpassning. Rapport 2017:7. 59 p. (in Swedish).

Syngenta 2014. Syngenta to acquire Lantmännen's winter wheat and winter oilseed rape businesses in Germany and Poland. Accessed 16 June 2014. http://www4.syngenta.com/media/media- releases/yr-2014/16-06-2014

USDA 1948. Lumber Production in the United States, 1799-1946. U.S. Department of Agriculture. 566 p.

Vorley, B. 2001. The chains of agriculture: sustainability and the restructuring of agri-food markets. World Summit on Sustainable Development. International Institute for Environment and Development, London, UK.

Zilberman, D., Wesseler, J., Schmitz, A. & Gordon, B. 2018. Economics of Agricultural Biotechnology. In: The Routledge Handbook of Agricultural Economics. Routledge. p. 670–686. https://doi.org/10.4324/9781315623351-36

Åhman, I., Andersson, M., Lagerkvist, C.J., Nohren, E., Yngwe, K., Borring, P. & Gunnarson, B.O. 2016. Mistra Biotech seminar " Framtidens mat i nordligt klimat - klarar vi oss utan inhemsk växtförädling?" at Almedalsveckan, Visby, July 2016. (in Swedish).