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# The Impact of the COVID-19 Pandemic on Global and Asian Seed Supply Chains

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Trade in seeds is key to guarantee access to food across the globe. COVID-19 led to concerns that seed supply chains would be disrupted and that countries relying on imported seed would not have sufficient supplies for the upcoming season. Focusing on the impact of COVID-19 from the perspective of seed companies and the formal seed sector, this study shows that the global seed sector was reasonably resilient during the crisis, although seed companies headquartered in the Asia Pacific region were more negatively affected than their counterparts in other regions. The two main bottlenecks were the availability of staff in the seed production chain and in government administrations, and the distribution of seed to farmers. Building a more resilient seed supply chain will require policies to ensure the uninterrupted production and movement of seed during lockdowns; the further development of international seed supply chains; and the diversification of seed production. Digitalisation could also improve the availability of information on seed production and trade, enabling faster government responses to disruptions.

**Key words**: Vegetable seeds, digitalisation, international supply chain, Asia

**JEL codes**: Q12, Q13, Q16, Q17, Q18

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## Executive Summary

Following the COVID-19 outbreak, there were concerns that seed supply chains would be disrupted and that countries relying on seed imports would not have sufficient seed for the upcoming seasons. Many countries classified the food and agriculture sector (which includes seed) as “essential”, thereby facilitating the free movement of goods and allowing employees to continue working in this sector. However, during the first months of the pandemic, free movement in the agro-food sector was not guaranteed in many Asian countries. In addition, other restrictions, such as lockdowns, social distancing measures, reduced mobility, and lack of air transportation, affected the seed supply chain on a global scale.

To better understand the impact of COVID-19 on the seed supply chain, the OECD, in cooperation with the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF), and with assistance from the International Seed Federation (ISF), the Asia and Pacific Seed Association (APSA) and the World Vegetable Center (WorldVeg), carried out a detailed analysis from the perspective of seed companies. The report focuses on vegetable seeds in the Asia Pacific region, which account for over half of the international seed trade in the region.

Data for this report come from online surveys of seed companies. Three surveys were carried out among Asian seed companies by APSA and WorldVeg in April, May and August 2020. The OECD and ISF provided input in the August survey. A separate set of surveys was carried out by the OECD among Japanese seed companies in September and October 2020.

The survey responses indicate that seed trade in the Asia Pacific region was negatively affected by the COVID-19 pandemic, and that the recovery has been slow. In the May 2020 survey, over 60% of the respondents stated that seed demand had dropped. While for most sectors, demand started to recover by August 2020, demand for vegetable seed had fallen even further. Seed business operations (international and domestic seed shipments, input delivery and labour availability) experienced little improvement between the May and August surveys. The greatest impact was reported for international seed shipments, with over 90% of seed companies indicating a negative impact. The only areas where slight improvements were reported were access to finance and research and development.

In August 2020, around one third of the respondents from the Asia Pacific region indicated that they had fewer export orders and another 36% expected this to become a problem. The main bottleneck for seed exports appeared to be finding appropriate freight solutions, with 58% of respondents reporting this as a problem. At the root of this problem were the restrictions in international air traffic in the Asia Pacific region, which reduced the number of transport options and led to an increase in the costs of seed shipment. At the same time, courier services, which are needed to get paperwork to the destination on time, continued to be a key bottleneck, reported by 53% of the respondents.

The survey results also show that seed companies with headquarters in the Asia Pacific region experienced a larger decrease in seed demand than their counterparts outside the region, and had more difficulties acquiring the necessary import and export permits, finding the right freight solutions, getting seed storage at the port of entry, and distributing the seed in the destination country.

The survey results for Japanese seed companies indicate a less severe impact of COVID-19. The Japanese seed companies reported that by autumn 2020 they were not experiencing any major obstacles to importing seed. The companies also expected almost no problems in seed supply for the 2021 spring planting season, mainly because they had sufficient seed stocks to cope with emergencies. This positive view of the Japanese seed sector was confirmed by information received from the ISF that overall global seed demand has not decreased significantly. This gives a more optimistic outlook for the future of the international seed sector.

While Asian seed companies experienced greater negative impacts on demand, transport and human resources, at a global level, the seed sector has been reasonably resilient to COVID-19. However, if the restrictive measures to deal with the COVID-19 pandemic continue for a longer period, it is likely that the seed supply chain will be affected. First, it might become more difficult to ensure the supply of high quality seed in the future. Travel restrictions have hampered seed company specialists from giving on-site instructions or carrying out inspections and quality controls at seed production locations. Furthermore, the restrictions are putting constraints on seed production, transportation and marketing, which can all contribute to an increase in seed prices. The longer-term impacts of COVID-19 on the seed supply chain are difficult to estimate, not only because of the uncertainty around when restrictive measures will be lifted, but also because of the lack of accurate information available to policy makers that would help mitigate the risk of COVID-19 on the seed sector

The following policy recommendations can strengthen the resilience of the seed supply chain and mitigate or avoid the negative effects of the current pandemic and future crises:

- *Ensure production and movement of seed during a crisis:* It is crucial that the agricultural sector remains classified as "essential" in all countries to ensure the continued production and movement of seed during any crisis. At the same time, it is important to carefully consider any sudden changes to existing regulatory frameworks (e.g. certification and phytosanitary requirements, customs clearance) and prevent any technical barriers to trade when the relevant authorities are short of staff and under pressure, and thus cannot easily adjust to changing requirements. Communication and coordination between governments and authorities is even more important during a crisis to avoid interruptions in the seed supply chain.
- *Support the development of international seed supply chains and the diversification of seed production*: Most countries cannot sufficiently supply their farmers with seed of their choice with their own national seed production. Thus, internationally interconnected seed supply chains have considerable benefits for the majority of countries in terms of their economic stability and activity. The economic risks of nationalising seed production are higher than maintaining international seed supply chains and developing policies to mitigate the associated risks. Supporting the seed sector to diversify seed production in different locations worldwide is beneficial for the stability of seed supply and the availability of diverse varietal choice for local farmers.

  Government policies should focus on the support and further development of the international regulatory framework for seed production and trade. This would include active participation in the regulatory work of international organisations such as OECD Seed Schemes, UPOV, FAO and ISTA.

  Developing countries should be supported to develop their national seed sector in line with the international regulatory framework e.g. via capacity-building activities or twinning programmes. This could not only increase their potential to participate in the international seed supply chain as seed-producing countries but would also enable local farmers to access high-quality seed of modern varieties, delivering both local and global benefits. This has positive implications for food security, as well as for the incomes of seed-producing farmers and breeders.
- *Support digitalisation of the seed supply chain:* The COVID-19 pandemic accelerated digitalisation in many areas. In those countries where seed production and certification were supported by digital tools, the impact of disruptions to staffing and travel were less severe. Governments should support the digitalisation of the international seed supply chain and should also aim to reduce the digital divide between and within countries. Inter-governmental digitalisation initiatives may reduce these digitalisation inequalities by providing a wide range of users with access to digital platforms. Increasing the digitalisation of certain procedures in the seed supply chain, e.g. the seed quality or phytosanitary certification systems, and creating more

open data policies would be a proactive step for policymakers to support more resilient seed systems.

- *Ensure public availability of information on seed production and supply chains:* Governments could take coordinated responses, including generating and sharing real-time data and implementing early warning systems which would allow them to react quickly to disruptions in the seed supply chain. Taking into account the specificities of the seed supply chain, the most realistic approach would be to collect information and trace ongoing seed production in different countries and share this information on an international platform. This would be particularly important in those countries where farmers have not developed a robust information system on input supplies. The OECD Seed Schemes is currently working on the digitalisation of their varietal certification system, including the development of a database of ongoing seed certification activities. Once this system is developed, it has the potential to be the basis of an international data sharing platform of ongoing seed production in participating countries.

# 1. Introduction

The COVID-19 pandemic has caused a severe global health, economic and social crisis. The OECD estimates that global GDP dropped by 3.4% in 2020. Even though global output is expected to rise above the pre-pandemic level by the middle of 2021, progress will be uneven, with many countries experiencing a slower recovery (OECD, 2021[1]).

Following the COVID-19 outbreak, governments focused their immediate attention on health and economic recovery (OECD, 2020[2]), including policies to stop the spread of the disease. At the beginning of the COVID-19 outbreak, there were concerns that food supply chains would be disrupted, leading countries to classify the food and agriculture sector (which includes seeds) as “essential”, thereby facilitating the free movement of goods and allowing employees to continue working in this sector (International Seed Federation, 2020[3]).

However, during the first months of the pandemic, free movement in the agro-food sector was not guaranteed in many Asian countries (APSA, 2020[4]). In addition, other restrictions, such as lockdowns or lack of air transportation (International Seed Federation, 2020[5]), caused several unintended disruptions throughout the global seed supply chain (Erhie, Nevin and Osinubi, 2020[6]). These disruptions in seed production, seed certification and international trade of seed affected the seed sector, farmers and the global food chain.

The COVID-19 pandemic has revealed weaknesses and vulnerabilities in global seed supply chains (WBCSD, 2021[7]), and underscored the importance of improving the resilience of these supply chains and of food systems more broadly. As indicated in a recent OECD report (2021[8]), global food systems have an ambitious triple challenge:

a) providing food security and nutrition for a growing global population;
b) supporting livelihoods for those working in the food supply chain; and
c) Contributing to environmental sustainability.

The seed sector is a crucial part of global food systems. It plays an important role in maintaining or increasing crop yields to feed a growing global population, while at the same time helping farmers adapt to climate change and environmental pressures[1].

At the request of the Japanese Ministry of Agriculture, Forestry and Fisheries, the OECD, in cooperation with the International Seed Federation (ISF), the Asia and Pacific Seed Association (APSA) and the World Vegetable Center (WorldVeg), conducted a study to assess the impact of the pandemic on the seed production chain, mainly on the Asian continent and with a specific focus on Japan. The goals of the study were to identify policy measures that would mitigate the negative impact of the current pandemic on seed supply and food production chains, while improving the resilience of this vital part of the economy to better withstand a future large scale shock.

Section 2 of this report describes the structure and organisation of the global seed supply chain. It provides a historical overview of seed production, describes the four main stages of the seed supply chain, lists the top exporters and importers of seed in both value and volume terms and outlines the main benefits and challenges of global seed supply chains. Given the importance of vegetable seeds in Asia, section 3 describes the vegetable market in Asia and in Japan. Section 4 addresses how COVID-19 has affected seed supply chains globally and assesses the potential longer-term impacts. Using survey responses, the impact on seed companies in Asia and in Japan is examined in detail. Section 5 identifies policy measures that can help mitigate the negative impact of the current pandemic on the seed supply chain and can improve the resilience of the sector.

# 2. Structure and organisation of the global seed supply chain

## 2.1 Historical background

Seed production depends heavily on the availability of high quality seed varieties. Until about two centuries ago, crop improvement was in the hands of farmers. This continued until Darwin and Mendel laid the cornerstones of modern plant breeding in the late 19th century. During the 20th century, knowledge of genetics, plant pathology, and entomology grew, and the process of improving many economically important crops shifted to professional plant breeders, often in integrated companies which carried out activities from variety development to seed production and distribution. In the past century, plant breeders have made enormous contributions to increasing food production throughout the world.

The commercial seed industry started around the 1740s with the establishment of the earliest known seed company Vilmorin (1743) and was followed by Tezier (1785), Groot (1813), Comstock (1829), Takii (1835) and several others. The 1850s saw the involvement of the public sector not just in plant breeding, but also and in the protection of farmer and consumer interests. This was also the period that saw the birth of modern plant breeding. New companies were established such as KWS (1856), Asgrow (1865), Sluis and Groot (1867), Royal Sluis (1868), Weibull (1870), Vander Have (1879), Clause (1891) and many others (Bruins, 2009[9]).

[1] However, the seed sector is facing a number of trade-offs and contentious issues associated with plant breeding. The OECD study on “Making Better policies for Food Systems” examines whether such trade-offs are based on facts, the interests of key groups or values, and how policy makers can best manage these issues to meet the triple challenge (OECD, 2021[8]).

The first national seed associations were established more than a century ago, such as the American Seed Trade Association (1883), Dutch Seed Association (1909), Polish Seed Association (1919), Italian Seed Association (1921) and the Canadian Seed Trade Association (1923).

In the 20th century, the seed industry entered a period of transition and modernization. The seed sector, both public and private, continued to grow, and science and commerce expanded. In the first decades of the 20th century, seed traders felt a clear need to establish harmonised trade rules, and this led to the establishment of the International Seed Trade Federation (FIS) in 1924. The desire to protect the fruits of their labour led plant breeders to form the International Association of Plant Breeders (ASSINSEL) in 1938. FIS and ASSINSEL formally merged to become the International Seed Federation (ISF) in 2002.

The seed industry went through several waves of consolidation (OECD, 2018[10]), (Schenkelaars, de Vriend and Kalaitzandonakes, 2011[11]):

- A first wave occurred in the 1930s, when hybrid seeds were introduced. New commercial seed firms emerged (including Pioneer Hi-Bred, now part of Corteva Agriscience), which adapted and improved varieties developed through public research.
- A second wave occurred in the 1970s, around the same time as the intellectual property regime for plant breeding was strengthened via Plant Variety Protection (PVP) and patents. Several pharmaceutical, petrochemical and agrochemical companies in the United States and Europe started a process of mergers and acquisitions. However, many seed firms remained independent and maintained their market position. Over time, several multinationals divested their seed assets.
- A third wave of structural change started in the 1980s, driven by biotechnology. A small number of large agrochemical multinationals invested heavily in these new technologies, both through in-house R&D and by acquiring smaller players. This third wave was characterised by strategic mergers and acquisitions to obtain access to varieties, traits, and tools, leading to the current consolidation of integrated firms (OECD, 2018[10]) (Schenkelaars, de Vriend and Kalaitzandonakes, 2011[11]) In addition to these consolidations, many small- and medium-sized breeding companies were established.

Several studies attribute over 50% of total yield increases to the contribution of better varieties (Fernandez-Cornejo, 2004[12]) and the percentage contribution of improved genetics to yield increases has continued to grow steadily. During the first wave of consolidation, that saw the introduction of hybrid maize in the 1930s, the United States broke a decades-long pattern of stagnating yields that eventually enabled a seven-fold increase in the US maize yield (OECD, 2018[10]). A study carried out by the National Institute of Agricultural Botany (NIAB) in the United Kingdom showed that increases in UK cereal yields since 1982 were mostly due to better varieties, putting the relative contribution of genetic improvement at 88% for cereal crops and rapeseed (Mackay et al., 2010[13]).

The first half of the last century also saw the start of a period in which several international bodies were created to set standards and regulations and provide an enabling environment for the seed industry. These bodies include the International Seed Testing Association (ISTA) created in 1924, the International Plant Protection Convention (IPPC) created in 1951, the OECD Seed Schemes created in 1958 and the International Union for the Protection of New Varieties of Plants (UPOV) created in 1961.

A number of regulatory developments occurred in the 1990s and 2000s. In 1991, the revision of the UPOV Act introduced, among others, the concept of Essentially Derived Varieties (EDV); in 1993 the Convention on Biological Diversity (CBD) entered into force; in 1994, the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPs) was signed and in 1995 the World Trade Organization (WTO, replacing the GATT) was established. In 2000, agreement was reached on the Cartagena Protocol on Biosafety, which entered into force in 2003. Of particular interest to the seed industry was the International Treaty on Plant Genetic Resources for Food and Agriculture (IT-PGRFA) which entered into force in 2004.

More recently, the seed industry went through another wave of consolidation, with the mergers and acquisitions of Dow-Dupont, Bayer-Monsanto and ChemChina-Syngenta. BASF entered into the seed sector and second-tier seed companies such as Limagrain, DLF and KWS continued to expand through acquisitions. The OECD assessed the implications of this latest wave of mergers and found that there is considerable variation across different crops and countries (OECD, 2018[10]). The seed markets for sugar beet, cotton, sunflower, maize, and rapeseed were typically more concentrated, while those for potato, soybean, wheat and barley are much less concentrated. Some countries appeared to have systematically higher degrees of market concentration across different crop seed markets. The study did not find any clear evidence that increases in market concentration raised seed prices or reduced innovation.

### Box 1. OECD Seed Schemes

Since the 1960s, the OECD Seed Schemes has been certifying the varietal identity and purity of seed lots destined for international trade. As of 2020, 61 countries (both developed and developing) participate in the OECD Seed Schemes.

The Schemes facilitate the movement of high-quality agricultural seeds across borders by harmonising certification standards and procedures. This harmonisation helps to improve domestic production, develop export markets, and provides farmers, plant breeders and authorities with reassurance as new markets open up. As such, many participating countries have now adopted OECD rules and regulations as part of their national laws.

The ultimate goal of the seed schemes is to ensure that farmers can trust the seed they are buying. In 2016-17, the OECD Seed Schemes certified 1.2 billion kg of seed, roughly a third (28%) of the total global exports of field crops (pulses, cereals, industrial crops and forages). Currently, over 60 000 varieties of agricultural crops are registered under the OECD Seed Schemes.

The OECD Seed Schemes form a key part of the international regulatory framework governing the seed sector and works in close co-operation with other international seed-related organisations.

## 2.2. The seed supply chain

The seed supply chain covers the process of activities from the use and (re)combination of different plant genetic resources, to the creation of new plant varieties through selection and multiplication, to the marketing or distribution of specific new seed varieties to farmers.

Generally, four main stages are distinguished in the seed supply chain (OECD, 2018[10]):

- Plant breeding, where R&D leads to new and improved varieties.
- Seed production, which is typically outsourced by plant breeding firms to contract farmers.
- Seed processing, where seeds are dried, cleaned, sorted, treated with insecticides and fungicides, and packaged for distribution and sale.
- Seed distribution, where seeds are sold to end users such as farmers and (horticultural) plant raisers and growers.

### *Plant breeding*

The seed supply starts with the development of new and improved varieties by the plant breeding and seed sector. This variety development process begins by collecting and selecting the most suitable germplasm to develop new varieties. A plant breeder will first create the desired diversity from which the

selection process can begin. This often involves one or more steps of crossing the germplasm, or other approaches to create genetic variation, e.g. through new breeding technologies, such as genome-editing like CRISPR. This is then followed by several years of multi-environment selection to identify the most suitable candidates for a certain area. Once the desired new varieties that grow well in their intended environment have been identified, sufficient quantities of these varieties need to be produced.

### *Seed production*

The production of high-quality seed is fundamental to modern agriculture. Most annual crops are established each season from seeds, and seed quality can have a major impact on potential crop yield. This production process of high-quality seed is a very precise activity, which involves many steps to protect the genetic integrity of the seed, including ensuring the integrity of the planting seed, properly identifying and labelling plants and fields, planting seeds on clean land which has not been used to grow the same crop in the recent past, removing rogue plants, or off-types (plants which are not true to the variety's characteristics), and employing physical isolation – via mesh cages, distance isolation, time isolation or hand pollination – to ensure that pollination only occurs among plants of the desired variety (UC Davis, 2020[14]). Additionally, to ensure good hygiene and prevent transmission of weeds or diseases, the planting and harvesting equipment needs to be sanitized.

The OECD Seed Schemes provides an internationally-harmonised seed varietal certification system for participating countries and beyond. These certified seeds are produced – and officially controlled – according to a set of harmonised procedures put in place in the 61 participating countries. With membership open to OECD, UN and WTO countries, the aim is to stimulate the production and use of high-quality seeds. By ensuring consistently high standards, the Schemes contribute to its members' evolving agriculture and trade policies (Box 1) (OECD, 2020[15]).

Seeds can serve as the delivery system for more than improved genetics. New seed varieties are often also associated with new planting and production methods and crop protection strategies that can enhance the efficiency of agriculture and reduce its environmental impact, for example by improving tolerance to stress.

### *Seed processing*

Seed processing includes all processes aimed at improving the quality and handling of the seed after harvest. The processing starts with checking the moisture content of the seed. If it is high, the seed needs to be dried to reach an optimal level of moisture content which will positively affect its viability. Seed producers increase the physical and genetic purity of the seed by removing all foreign materials, including weeds and infected or unripe seed. Seed processing also includes sorting seed by weight or size and sometimes coating the seed to facilitate precision sowing and improve germination, e.g. by using pesticides and fertilisers in the coating material. The final step is the packaging of seed into containers. The size of seed containers varies greatly: from small packages for hobby gardeners to sizeable bags for large-scale farmers.

### *Seed distribution*

Wholesale distribution is often controlled directly by large seed firms, sometimes through licensing agreements. At the local level, retail distribution of seeds often takes place through intermediaries, such as farmer-dealers or agricultural supply stores. The precise structure of the distribution stage differs from region to region. In some countries, agricultural cooperatives play an important role in distribution of agricultural inputs, including seeds (OECD, 2018[10]). In the case of vegetable seed business, these activities (breeding, distribution, processing and in some extent the production) are fully integrated.

### *The global nature of the seed supply chain*

Farming has undergone several revolutions in the past few decades that have resulted in increased availability of high-quality seed for improved crop varieties, more effective methods of weed and insect control, smart fertilizers, and (adoption of) modern power equipment (World Food Programme, 2020[16]). The seed industry has played a vital role in these revolutions. During this period, the sector expanded its seed production capability, implemented more effective maintenance of genetic purity, and developed methods for more efficient rapid seed multiplication of new varieties.

As noted above, production of high-quality seed requires many steps to protect the genetic integrity of the product (UC Davis, 2020[14]). In most countries, production of high-quality seed is subject to stringent laws and regulations that guarantee the genetic and physical purity of the seed lot. All the steps require a considerable amount of human labour, and often in short, peak periods of time, such as for sowing or harvest.

The production path of seeds can cover multiple countries before reaching the customer. Table 1 gives an overview of the many steps involved in the production process, which is very similar for most seed companies, whether they are located in Japan, elsewhere in Asia, or throughout the rest of the world. Each of the steps in this process can take place in a different country. The generation of genetic variation and the crossing of parental germplasm can take place in one or more countries, often where the lead breeders for that crop are located. This is followed by several years of selection of the offspring in multiple countries with different weather, climate and soil conditions, taking into account the best conditions for cultivation to determine the best fit for the candidate varieties. Many seed companies speed up the selection process by producing (Hein, 2020[17]) in the opposite hemisphere (counter-season production), allowing for at least two generations to be produced per year. Given that many seed firms are based in the Northern Hemisphere, the main countries for this counter-season production are Chile, Argentina, Australia, South Africa, New Zealand, and Peru. Counter-season production contributes to shaping the international nature of the seed production chain.

**Table 1. The seed production chain involves many steps**

| Main step | Detailed step | Explanation |
|---|---|---|
| Plant breeding | Plant breeding methods | Creation of new variation |
| | Selection of offspring | Multi-locational trials to select for local adaptation |
| | Fixation of characteristics | Ensuring homogeneity |
| | Company and Official trials | Assessment for distinctness, uniformity, stability and performance |
| Seed production | Sowing of seed production | Once all official trials are passed, seed production can start |
| | Good Seed Production Practices | Good agriculture practice on the seed producing field<br>Implementation of the seed production method required by the variety (e.g. crossing of parent lines in case of hybrid) |
| | Field inspection | Control of the field to ensure genetic integrity and health of the seed |
| | Fresh seed from field | Seed from the field may come with impurities, e.g. branches, stones, dust |
| Seed processing | Moisture testing | Too much moisture reduces viability of the seeds |
| | Drying | Most seeds come out of the field with too high moisture content |
| | Pre cleaning | Removes larger impurities |
| | Fine cleaning | Removes all remaining impurities |
| | Grading (gravity separation) | Ensures all seed are more or less of the same size and weight |
| | Seed treatment | Improves seed quality, protects the seed against pests and diseases and ensure good start during germination |
| | Seed packaging | Maintain germination and reduce seed deterioration rate |
| Seed distribution | Sale to farmer/grower | Guarantees high quality production with high quality seed<br>(good germination and varietal purity) |

Note: Each of these steps can occur in a different country.

Once one or more potential commercial varieties have been identified, then several additional steps need to take place depending on the crop and variety, such as the production of basic seed, seed treatment, production of hybrid seed, treatment of the hybrid seeds, commercial packaging, and shipment to the final customer. These highly-specialized steps can take place in different countries, carried out by either the seed company itself, or through outsourcing to overseas farmers and companies. Figure 1 illustrates this by showing the international seed production chain for tomato seed.

### Figure 1. International production chain of tomato seed


Source: International Seed Federation (ISF, 2021[18])

Before a new variety reaches the market, it has often travelled across multiple countries. It is therefore important that the relevant national seed authorities communicate, collaborate and harmonise seed regulatory measures. Such international alignment can be achieved when national seed authorities are members of the relevant seed-related international organizations, such as the OECD Seed Schemes, ISTA or UPOV.

For the private sector, such coordination and harmonisation can be achieved through seed sector participants and farmers organising themselves into national seed and farmer associations. These national associations can then join regional seed associations or connect at the global level to ISF or the World Farmer's Organisation, which can in turn represent the interests of the seed sector and farmers in intergovernmental organisations during the development of international seed regulatory frameworks. One recent example of collaboration between intergovernmental organisations is the World Seed Partnership (World Seed Partnership, 2021[19]), an informal cooperation between the OECD Seed Schemes, UPOV, ISTA, ISF and WFO, which aims to support the development of the formal seed sector around the world.

## 2.3. Trade in seeds

Data on the volume and value of seed exports and imports are collected by a number of organisations, including the International Seed Federation (ISF), the Food and Agriculture Organization (FAO) and the International Trade Centre (ITC) of the WTO. The methodologies used to collect this data vary by organization. For this study, several sources are used, prioritizing the most recent available data. Tables 1 and 2 are based on data collected by the ISF (ISF, 2018[20]). A detailed breakdown of the values in these tables is provided in Annex A.

### *Main seed exporters*

In 2018, global seed exports reached 5.7 million metric tonnes (MT), which corresponded to USD 13.8 billion (ISF, 2018[20]). In volume terms, France exported the highest volume of seeds worldwide in 2018, at

over 610 000 metric tonnes (MT) (about 10% of the global seed export), followed by the United States, at 481 000 MT, and Poland, Canada and Hungary (Table 2). In the Asia Pacific region, India is the largest seed exporter in volume terms with over 37 000 MT, followed by New Zealand with almost 29 000 MT, and then the People's Republic of China (hereafter "China"), Australia and Japan.

Globally and in the Asia Pacific region, the largest portion of these exports concerns field crop species, such as maize, wheat, soybean, sunflower, barley, rapeseed, and rice. The seed of these species are in general much bulkier and heavier) than seeds of vegetable crops (Box 2).

### Table 2. Top five seed exporting countries in the world and in Asia in 2018

| Volume | | | | Value | | | |
|---|---|---|---|---|---|---|---|
| World | Metric tonnes | Asia | Metric tonnes | World | Million USD | Asia | Million USD |
| France | 610 920 | India | 37 174 | Netherlands | 2 201 | China | 189 |
| United States | 481 086 | New Zealand | 28 755 | France | 1 851 | New Zealand | 135 |
| Poland | 262 584 | China | 25 600 | United States | 1 831 | Thailand | 133 |
| Canada | 190 778 | Australia | 17 421 | Germany | 846 | India | 133 |
| Hungary | 188 675 | Japan | 9 945 | Hungary | 453 | Japan | 123 |

Source: ISF (2018[20]).

### Box 2. Comparing the volume and value of seed trade

The size and weight of agricultural and vegetable seed can vary considerably between species or even between varieties of the same species. This difference can easily be 100-fold. For example, the weight of 1 000 kernels of maize is between 250-400 g compared to 1 000 tomato seeds, which usually weigh between 2 – 4 g. This also affects the size of a seed lot, as for bulky seeds, the same number of seed in a lot is heavier.

The value of a seed lot depends on many factors and can vary between species and varieties. Seeds of new and innovative varieties are usually more expensive as the R&D and production costs are higher. In return, their performance is potentially higher which is reflected in higher yield, higher biotic or abiotic stress resistance, easier crop handling or increased crop quality.

The volume and the value of a seed lot do not necessarily correlate, which explains why the list of the largest seed exporters and importers by volume and by value do not coincide. Usually, vegetable seed of high-performing varieties (e.g. tomato, sweet pepper, cucumber) are light-weight and expensive. However, an individual plant can produce a high return for the grower. Seed for agricultural staple crops (e.g. wheat, rice and maize) are bulkier and usually cheaper. These crops are grown in larger fields and sown in high density which requires more seed. In this case, an individual plant can produce less return for the grower.

It is difficult to find publicly-available references for seed prices, as it is common practice in the seed sector for seed companies to be in direct contact with producers to determine seed prices individually. One example to illustrate the difference between seed value and volume is to compare seeds of a hybrid maize variety with a hybrid tomato variety. In 2020/21 in the same country 50 000 seed of a hybrid maize variety was offered for sale for EUR 91 (EUR 1.8 /1 000 seed (~ 325g) (Limagrain, 2020[21]) while 500 seed of a hybrid tomato variety was offered for sale for 210 EUR (EUR 420 /1000 seed (~3g) (Syngenta, 2021[22]).

In value terms, the Netherlands is the world's largest seed exporter, with a total of USD 2.2 billion covering almost 16% of global export value, followed by France and United States who each export around USD 1.8 billion (13%). In Asia, China leads, at a total of USD189 million, followed by New Zealand, Thailand, India and Japan, all with values close to USD 130 million.

In most cases, field crops account for the highest value of the total exports because of the high traded volume, but in some countries, notably The Netherlands or Chile, the value of vegetable seeds is higher than that of field crops. In Asia, with the exception of Australia and New Zealand, the value of the vegetable seeds exceeds the value of field crops seeds by a significant factor.

### *Main seed importers*

In 2018, global seed imports reached 5.6 million metric tonnes, which corresponded to USD 13 billion[2] (ISF, 2018[20]). Belgium is the largest seed importing country in volume terms, with imports in 2018 reaching more than 650 000 MT or 11.6% of the total seed import, followed by the Netherlands with 600 000 MT (Table 3). Many international seed trading companies have headquarters in these two countries and, thus, the imported seeds are often re-exported to other countries. The volume of field crops seeds largely outweighs the volume of other crop groups. In the top 3, over 97% of imported seed are from field crops species. In Asia, Japan imports the largest amount of seed, with over 71 000 MT, followed by Viet Nam with 49 000 MT and Australia with 33 000 MT.

**Table 3. Top five seed importing countries in the world and in Asia in 2018**

| Volume | | | | Value | | | |
|---|---|---|---|---|---|---|---|
| World | Metric tonnes | Asia | Metric tonnes | World | Million USD | Asia | Million USD |
| Belgium | 656 677 | Japan | 71 581 | Netherlands | 1 095 | China | 372 |
| Netherlands | 600 190 | Viet Nam | 49 600 | United States | 996 | Japan | 274 |
| Italy | 343 878 | Australia | 33 180 | France | 978 | Australia | 129 |
| Germany | 266 319 | India | 32 698 | Germany | 683 | India | 127 |
| Spain | 258 775 | Indonesia | 27 773 | Spain | 593 | Korea | 113 |

Source: ISF (2018[20]).

In value terms, the Netherlands are the largest global importer of seeds, with imports accounting for over USD 1 billion, directly followed by the United States and France, both with almost USD 1 billion of imports. In Asia, China imports the largest value of seeds (USD 372 million), followed by Japan, Australia, India and Korea.

In most Asia-Pacific countries, the value of vegetable seeds imports exceeds the value of imported field crop seeds. This also explains why fewer countries from the Asia Pacific region participate in the OECD Seed Schemes. The OECD seed varietal certification system was historically introduced and accepted by the seed sector as an international benchmark for field crops and agricultural species, while the quality of vegetable seed has historically been controlled by industry itself through the use of standard category seed

[2] There is a slight discrepancy between the global seed export and import data compiled by ISF (in Chapters 2.3.1 and 2.3.2).This can be explained by the complexity of the international seed supply chain as well as with the challenges to collect information on the value of the international trade of seed. Seed can be exported and imported several times before reaching the final users. Between export and import the seed can go through different seed processing methods (e.g. sorting, coating) which can increase the value of the seed. Thus, the value of the exported seed after processing can be higher than the value of the imported "raw" seed. In addition, the ISF compilation based on official statistics and international seed trade reports received from seed companies. Sometimes seed companies do not report all international seed movements between their branches located in different countries as export or import.

(Box 4). However, as international seed trade of agricultural species grows in Asia, countries in the Asia Pacific region may become more interested in adopting the OECD agricultural seed standards. The OECD Secretariat collaborates closely with the Asia and Pacific Seed Association (APSA) to promote the OECD Seed Schemes in the region.

## 2.4. Benefits and challenges of the global seed supply chain

Over the past 50 years, the balance of plant breeding activity has shifted from the public to the private sector in many industrialised countries. This shift has been driven by changes in intellectual property rights protection, globalisation and pressure on public budgets (Heisey, Srinivasan and Thirtle, 2001[23]). The balance between public and private sector involvement depends on multiple factors, including time, country, crop and, perhaps most importantly, private firms' ability to earn returns on their research investments.

Plant breeding and the seed sector are R&D intensive. Major innovations, such as the application of modern genetics, the creation of hybrid varieties, the introduction of semi-dwarf characteristics and genetic engineering, initially increase the cost of research. However, in the long run, such techniques lead to a reduction in the cost of the cumulative research process as they can shorten the time needed for the development and introduction of a new variety to the market. Such forces have led to a strong specialisation and globalisation in the seed supply chain. The global seed supply chain involves many different groups of stakeholders who are involved in production, distribution and marketing of seed globally. These actors include farmers, seed growers, small and medium enterprises, large companies as well as research institutions, agricultural input dealers, civil society and local markets (FAO, 2021[24]). Global seed supply chains provide essential inputs at the beginning of agri-food value chains.

### *Benefits of the global seed supply chain*

A global seed supply chain provides numerous benefits (Michalowicz, 2018[25]), including:

- *Expanded market, leading to lower development costs*: Often varieties are developed to grow well in certain climatic conditions. In a global seed supply chain, such varieties can be sold to more countries with similar climatic conditions, thus leading to a reduction of costs per new plant variety.
- *Greater diversification at relatively lower cost*: For large R&D departments, covering multiple crop development programmes and combining different fields (e.g. genetics, plant pathology, molecular biology), it is relatively easier and less costly to breed varieties for another climatic region, or even breed an entirely different crop, as opposed to setting up the necessary R&D infrastructure from scratch.
- *Stability of supply*: In a globalised market, the seed sector can use optimal locations for seed production, incorporate different harvest times, and take advantage of localised expertise, thereby ensuring a stable supply of seed for farmers everywhere. It can also mitigate– the impact of extreme weather events and climate change by diversifying or relocating parts of its supply chain.
- *Increased efficiency*: With global seed supply chains, companies can choose to breed their varieties in one country, treat the seeds in a next, and produce hybrid seeds in a third, benefiting from the local conditions to create the greatest efficiency.
- *Greater ability to learn from each other*: Engaging with multiple cultures and communicating with customers and farmers in many countries, provides a larger pool of international expertise and knowledge that can be exploited when developing new varieties.
- *Increased food security*: A global seed supply chain increases access to modern, high-quality varieties, leading to yield increases and other benefits. For farmers, this may lead to higher

incomes and thus better access to food.[3] Higher yields can also translate into greater crop production, better access to food for consumers and global food security.

- *Environmental benefits*: The access to high quality seed enables farmers to apply modern agricultural production methods and increase yield on their land. Thus, less land use is required for the production of the same amount of food or feed.

Other benefits include the availability of high-quality seeds to more farmers, an incentive for countries which are aiming to increase the efficiency of their agricultural production. It can also lead to better stock management, as production and shipping can take place from multiple countries.

### *Challenges of the global seed supply chain*

Besides the many benefits to a global supply chain, there are also several challenges (Aswell, 2016[26]). Companies that ignore or mismanage such challenges risk higher costs and loss of efficiency. Below are some of the main challenges that can negatively impact a seed company's business:

- *Lower quality levels*: Production processes are never perfect, but the seed sector typically requires a certain quality level. Complexity and variability are part of any production process but new and unfamiliar sources may not be able to meet a seed company's quality standards; for example, those for seed germination or seed purity. Furthermore, choosing an unexperienced sourcing firm can open up questions and disputes about which party is to be held liable for any failures to meet certain standards and thresholds. Adhering to a robust system of international standards that guarantees high seed quality, such as seed testing rules by ISTA, seed certification by the OECD Seed Schemes or the phytosanitary standards based on the IPPC's guidelines, can help mitigate these risks of lower quality. Regions and countries with a higher level of implementation of these international standards tend to have a lower level of hunger on the global hunger index (GHI, 2020[27]). In addition to the application of international standards and procedures, national legislative and administrative measures, such as a robust national variety registration system or certified crop inspection requirements, can also play significant role in ensuring high seed quality.
- *Compliance and accountability*: When seed companies engage in global sourcing, they should ensure that acceptable working conditions and fair compensation practices are provided and that child or forced labour practices are avoided.
- *Long-range logistics and delays*: For seed companies it is important to have firm completion dates and shipping timeframes if they wish to receive an on-time product delivery. However, delays in shipment are common and can be caused by seed production or seed processing hold-ups or transit problems. Furthermore, if the product that is globally sourced is used as an input in the production process, then delays from a foreign source can derail processes such as seed production, seed treatment or packaging and increase related costs.
- *Language barriers*: Seed companies and their business partners from across the globe will be able to complete business deals, but often conduct their day-to-day business in a different language. Managers' instructions are often conveyed to line staff across these language barriers, with the risk of misunderstanding. When communications are not translated or interpreted perfectly, errors are likely to happen.

These challenges are not insurmountable. Seed companies that are willing take advantage of global cooperation opportunities can build their own breeding or trial stations abroad, or work with experienced partners who can help mitigate and perhaps even remove some of these risks. In order to support good production practices, most of the seed companies and seed producers implement a Quality Management

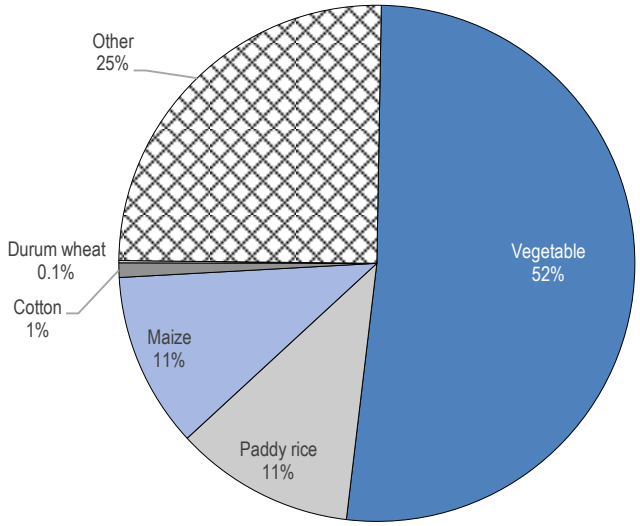
[3] Increased productivity can depress prices, so it may not be always the case that adoption leads to higher incomes.

System (QMS). A properly maintained process-based and continuously improved Quality Management System helps to mitigate risk around seed production and commercialization and ensure high seed quality by preserving the integrity of the seed production chain.

## 3. The vegetable market in Asia

The Asian continent is known for its rich diversity in crop production, especially vegetables. Over 275 million metric tonnes of fresh vegetables were produced on the continent in 2019 (FAO, 2021[28]). This large volume of vegetable production explains why vegetable seeds are the largest category of traded seed in the region (Figure 3). In 2019, over half of the seed trade in APSA countries was made up of vegetable seed, worth USD 738 million in exports and USD 897 million in imports (APSA, 2020[29]).

### Figure 2. Seed export shares in value terms in APSA countries (2019)




Source: APSA (2020[29]).

The most produced vegetable crops in Asia are tomatoes, cucumbers, gherkins, dry onions, and cabbages (FAO, 2021[28]). Production volumes differ considerably by country. The most produced vegetable crops in China are tomatoes and cucumbers, while in India it is dry onions, eggplants and cauliflowers, and in Japan, cabbages and dry onions. Annex B shows the production quantities of the main vegetable groups in a number of key Asian countries: China, India, Indonesia, Japan, Korea, Thailand and Viet Nam.

The diversity in vegetable production across countries is directly related to growing conditions and comparative advantage. Crops are produced where they grow best, and where the production and logistical infrastructure is optimal. This emphasises the interdependency of countries and the crucial role of trade in ensuring that seeds and vegetables can reach those countries that cannot produce them in sufficient quantities.

The seed market for major crops such as rice and wheat, as well as vegetables, in Asia has been growing rapidly. In Southeast Asia, the seed market is projected to register a compound annual growth rate (CGAR) of 6.4% for the period 2020-2025, whereas in South Asia, this is 4.1%. Because of limited land availability

and a growing population, farmers are increasingly adopting newer technologies in order to grow their preferred crops in various regions. Farmers also increasingly understand the value of certified and high-quality seeds and this has resulted in an increase in adoption of new varieties and also in a higher use of hybrids.

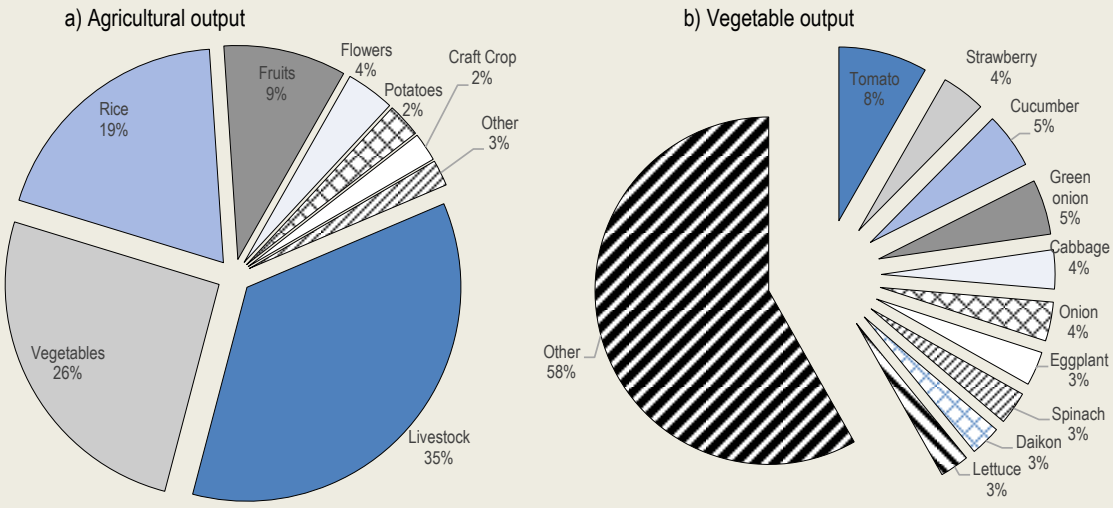
## Box 3. The vegetable market in Japan

Japan is a large domestic producer of vegetables (MAFF, 2018[30]). The Japanese Ministry of Agriculture, Forestry and Fisheries[4] records the production volume of around 90 different species. In 2017, the Ministry reported that almost 80% of the country's supply (around 11.5 million tonnes) was produced in the country itself (MAFF, 2018[30]). The remainder (around 3.1 million tonnes) was imported. Imports from China accounted for around 50%, followed by the United States (20%) and Thailand (4%).

The top five imported fresh vegetables are onion, pumpkin, carrot, onion, and gobō (root vegetable), which together accounted for about 70% of Japan's total imports of fresh vegetables. Onions accounted for more than 30% of the total imports (90% of which are from China). In terms of imported processed products, tomatoes take the lead with about 40% of the total, of which 30% are imported from the United States.

The total value of vegetable production in 2018 in Japan was JPY 2,321.2 billion (around EUR 8.7 billion) and accounted for about 30% of Japan's total agricultural output. The top ten vegetables and fruit vegetables produced in Japan were tomato, strawberry, cucumber, green onion, cabbage, onion, eggplant, spinach, daikon radish and lettuce, which together accounted for about 60% of the total value of vegetable production.

### Figure 3. Japan's composition of agricultural and vegetable output in value terms, 2018




Source: MAFF, Statistics on Productive Agricultural Income (MAFF, 2018[30]).

[4] The Ministry has designated 14 vegetables that are distributed nationwide and that are particularly important for high consumption as "designated vegetables". These 14 vegetables are cabbage, spinach, lettuce, fresh onion, dry onion, Chinese cabbage, cucumber, eggplant, tomato, green pepper, Daikon radish, carrot, taro, and potato.

The area planted with vegetables in 2017 was approximately 410 000 hectares, and the production volume was approximately 11.7 million tonnes. Both the acreage and the volume have been relatively stable for the past 15 years.

One major benefit of Japan's geography is that different weather conditions are found along the Japanese archipelago. This ensures a stable supply of vegetables throughout the year, because production areas can be rotated according to the season. For example, cabbage is produced in the more Southern Aichi prefecture during winter, in the Eastern Kanagawa and Chiba prefectures during spring, and in the more Northern Gunma prefecture during summer and autumn.

Seed production in Japan has a few characteristics that make the Japanese seed market slightly different from the seed markets in other parts of the world. First of all, rice is a major staple crop in Japan, and the relevant rice varieties are mainly developed by public organizations. Almost all of the rice varieties are bred locally in Japan. Another interesting characteristic is that new varieties of vegetable species are mainly developed and produced by private companies, and over 90% of the seeds are bred overseas.

# 4. Seed supply chain disruptions caused by COVID-19

## 4.1. Impacts of COVID-19 on the global seed supply chain

As mentioned in Section 2.2, the seed industry is globalised: a seed lot will often pass through multiple countries during the various stages of its supply chain before it reaches a farmer. In addition, the seed supply chain is time sensitive, with clearly-defined time slots for sowing and harvest, depending on the crop. This means that travel or transport disruptions will affect seed production, certification, and distribution, which in turn increases the price of seed (OECD, 2020[31]).

To stop or slow the spread of COVID-19, many countries restricted the movement of people and goods. Fortunately, most countries classified the food and agriculture sector as "essential", thereby guaranteeing the free movement of agro-food products (including seeds) and allowing employees in this sector to continue their work. However, during the first months of the pandemic, free movement in the agro-food sector was not guaranteed in many Asian countries (APSA, 2020[4]). In addition, travel restrictions in other sectors indirectly affected the agro-food sector (OECD, 2020[31]).

At the onset of the pandemic, the seed industry needed to respond to continuously changing regulations. To limit the spread of the virus, most governments introduced various regulations, including travel restrictions and social distancing. However, there was limited alignment among countries' policies, requiring seed companies to adjust their business according to divergent country regulations. In the initial phase of the pandemic, such regulations often changed day to day, making it difficult to prepare seed shipments accordingly. Transportation via air and land was restricted, certain airports were closed, and seed shipments had to be re-routed via one of the very few airports that were still open. This made it difficult to get seed to the customers or farmers on time.

Companies and seed associations have indicated that seed production and harvest has been disrupted in key areas because of travel restrictions for seasonal workers and delays in the supply chains for agricultural inputs (Erhie, Nevin and Osinubi, 2020[6]).[5] Air transport became more expensive due to the

[5] See, for example, (Bruins, 2020[49]) (Bruins, 2020[51]) (Bruins, 2020[48]) (Bruins, 2020[50]) (Bruins, 2020[52]) (Bruins, 2020[53]) (Bruins, 2020[54]), which examine the impact COVID-19 on the Seed Sector in Ireland, Italy, Portugal, Spain, Sweden, Switzerland and the Netherlands.

reduced availability of commercial flights (APSA and WorldVeg, 2020[32]), and this affected the seed supply chain, and the cost and timely delivery of seed. It also became more costly and took more time to ship items across borders, as a result of stricter sanitary and public health measures and fewer border staff. Furthermore, numerous processes, including production, trade, transport, documentation and sales, were limited by the reduced mobility of people.

In a recent study, the Wageningen Centre for Development Innovation (WCDI) assessed the impact of the crisis on the functioning of the seed sector in Ethiopia, Myanmar, Nigeria and Uganda (European Seed, 2020[33]). The study found that restricted mobility is one of the major effects of the lockdowns. Social distancing measures prevent the virus from spreading, but at the same time, limit access to labour and agricultural inputs. Field inspectors could no longer visit fields, compromising the production of quality seed, which is vital to guarantee future availability and ensure productive crops.

At the global level, the ISF reported that the effects of these disruptions were not significant and did not result in the collapse of the international seed supply chain. Many seed companies adjusted their operations to mitigate these adverse effects. Changes made include scaling back operations, offering flexible work arrangements, and proactively negotiating contracts and securing stockseed. However, there is widespread concern regarding how companies will be able to cope if the crisis and associated restrictions persist in 2021 and beyond. It is crucial that seed is available for the upcoming planting seasons to ensure sufficient global seed and food production.

At the start of 2020, most spring and autumn seed had already arrived in its final country of destination before travel restrictions were put in place. Some of the countries participating in the OECD Seed Schemes were concerned about how the pandemic may impact the 2020 autumn crop and seed harvest in the Northern hemisphere, but, as a result of careful preparations and the introduction of safety measures, all of these operations went smoothly. In general, the seed sector and the OECD seed varietal certification system showed reasonable resilience during the crisis through to the end of 2020 (OECD, 2020[34]). However, it is still uncertain whether seed required for the upcoming growing season(s) will arrive on time if the pandemic continues in 2021 and beyond (OECD, 2020[31]).

## 4.2. Survey of Asian seed companies

APSA and World Vegetable Center conducted three online surveys of seed companies that are members of APSA and have operations in the Asia Pacific region. The surveys were carried out in April, May and August 2020, and OECD and the ISF provided input into the August questionnaire (APSA and WorldVeg, 2020[35]) (APSA and WorldVeg, 2020[36]). This report focuses on the responses to the May and August surveys. The May and August surveys received responses from 74 and 73 seed companies, respectively. In both surveys, 59 of the responses are from seed companies with their main operations in the Asia Pacific region, and the remainder have their main operations outside the region. Around 60% of the respondents represent companies with less than 100 employees (APSA and WorldVeg, 2020[36]).

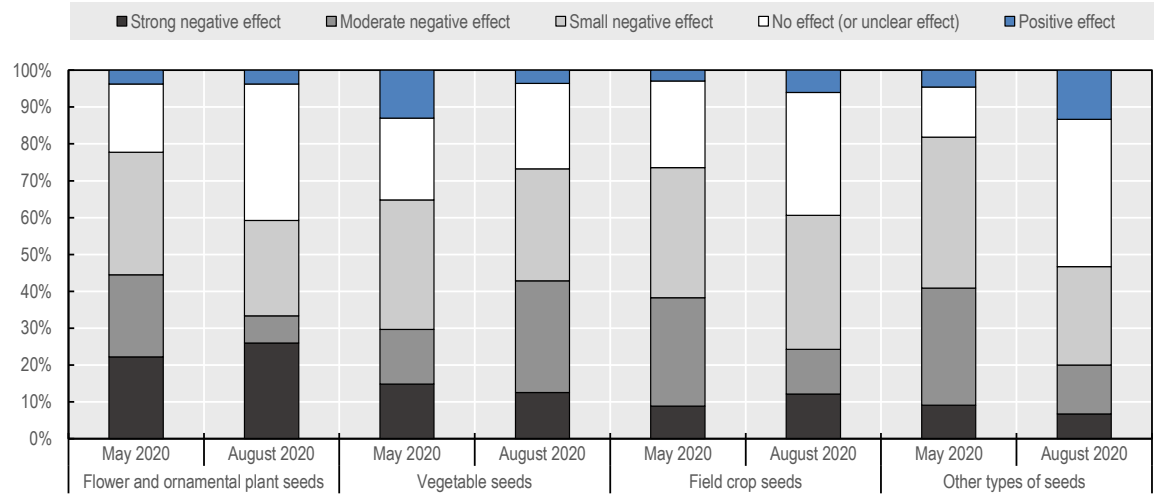
In a first set of questions, seed companies were asked to indicate whether they had experienced a strong negative, moderate negative, small negative, no (or unclear) or positive effect from COVID-19 on various aspects of their operations.

The responses from the August 2020 survey show that, while there were still adverse effects on seed demand, signs of recovery had started to emerge in certain sectors. Compared to the situation in May 2020, the situation in August had improved for most crops, but not for vegetables. For vegetables, 73% of the respondents reported an overall negative effect of the pandemic in the August survey, compared to 65% in May.

In the case of vegetable seed demand, seed companies witnessed two opposing trends. On the one hand, demand for small vegetable seed packages increased as many people started to grow their own vegetables during the confinement. On the other hand, seed demand from professional vegetable

producers decreased as restaurants had to close their businesses for a long period and were unsure whether they could maintain demand for, or sales of, fresh vegetables at pre-pandemic levels.

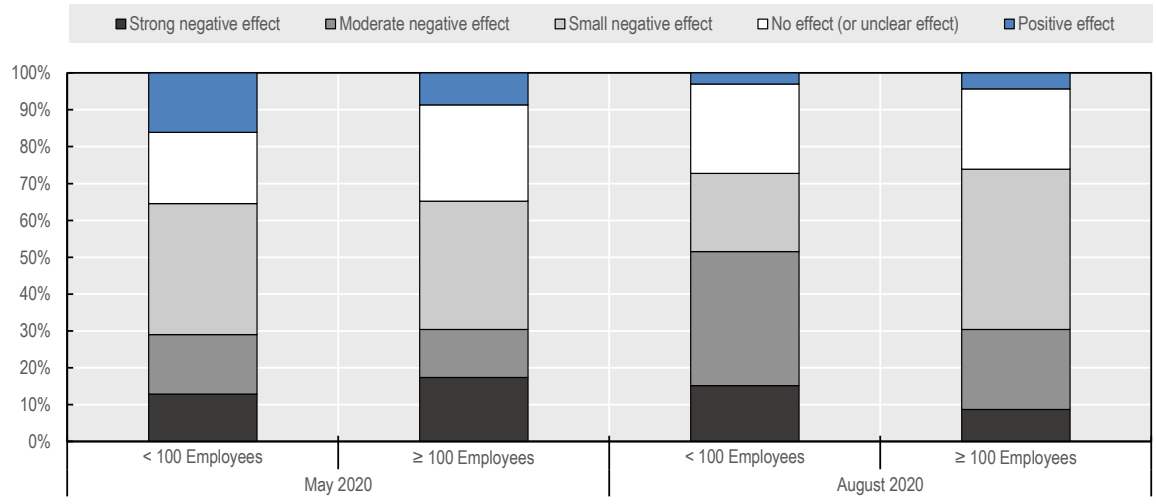
## Figure 4. Impact on seed demand in the Asia Pacific region (May 2020 and August 2020)




Source: APSA and WorldVeg (2020[36]).

When comparing vegetable seed demand in small seed companies (less than 100 employees) to large companies (100 or more employees), the impact of COVID-19 for both was reported to be relatively similar in the May 2020 survey. Around 60% of the respondents reported an overall negative effect, with the majority (35%) stating that the effect was slightly negative. However, by August 2020 small seed companies indicated that the impact on demand was more severe, with a higher proportion of companies reporting a moderate negative effect.

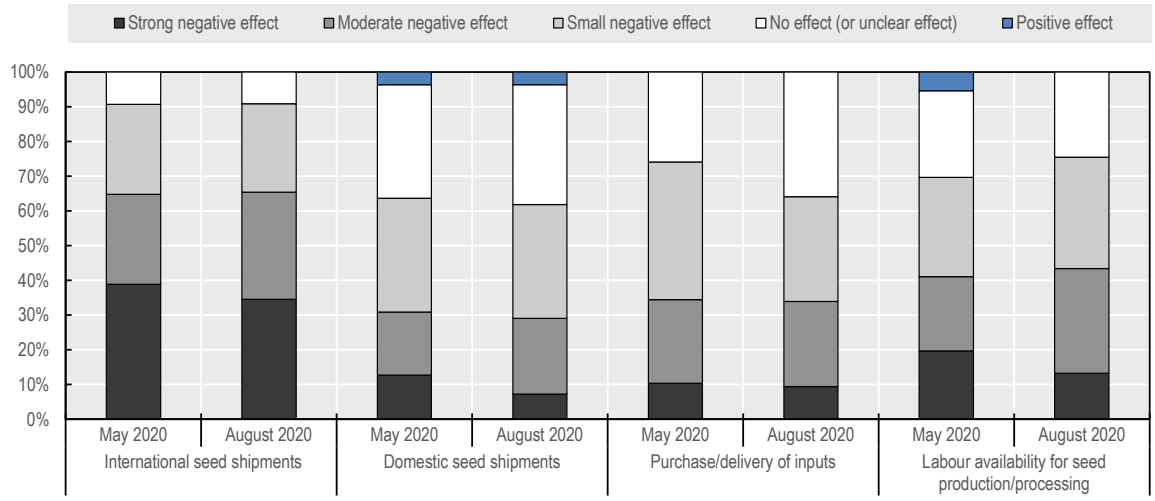
## Figure 5. Impact on vegetable seed demand in the Asia Pacific region, by company size (May 2020 and August 2020)




Source: APSA and WorldVeg (2020[36]).

Between May and August 2020, there was very little improvement in seed business operations, including international and domestic seed shipments, input delivery and labour availability. The greatest impact was reported for international seed shipments, with over 90% of seed companies indicating that they were having difficulties with their international seed shipments in May. The situation did not improve by August 2020. International shipments weren't the only cause for concern. In August, domestic shipments also faced more difficulties than in pre-pandemic times (62% of the respondents), as did purchasing of inputs for seed factories (64%) and obtaining labour for seed production and processing (75%).

## Figure 6. Impact on seed business operations in the Asia Pacific region (May 2020 and August 2020)



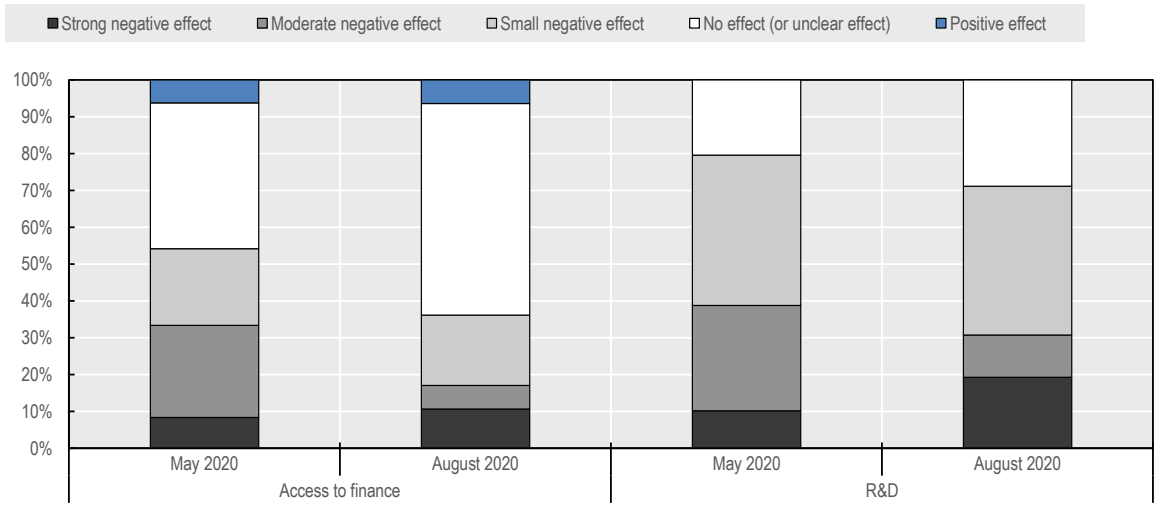

Source: APSA and WorldVeg (2020[36]).

Access to finance was one of the few areas where some improvement was reported. Whereas 54% of the respondents reported an overall negative impact of COVID-19 on access to finance in May, in the August survey only 36% of respondents reported this as a problem. The surveys also indicated very slight improvements in the area of research and development, where 71% of respondents reported difficulties in August compared to 80% in May (APSA and WorldVeg, 2020[32]).

In a second set of questions, seed companies were asked whether they were currently experiencing problems or were expecting difficulties in certain areas. In August 2020, around one third of the respondents from the Asia Pacific region indicated that they had fewer export orders and another 36% expected this to become a problem. The main bottleneck for seed exports appeared to be finding appropriate freight solutions, with 58% of respondents reporting this as a problem. At the root of this problem were the restrictions in international air traffic in the Asia Pacific region, which reduced the number of transport options and led to an increase in the costs of seed shipment. At the same time, courier services, which are needed to get paperwork to the destination on time, continued to be a key bottleneck, as reported by 53% of the respondents (APSA and WorldVeg, 2020[36]).

Several other aspects, which in pre-pandemic times were already a challenge, were aggravated, such as difficulties in the preparation of seed shipments; acquiring import permits; getting customs clearance at the port of entry and seed distribution in the destination country.

## Figure 7. Impact on R&D and access to finance for seed companies in the Asia Pacific region (May 2020 and August 2020)

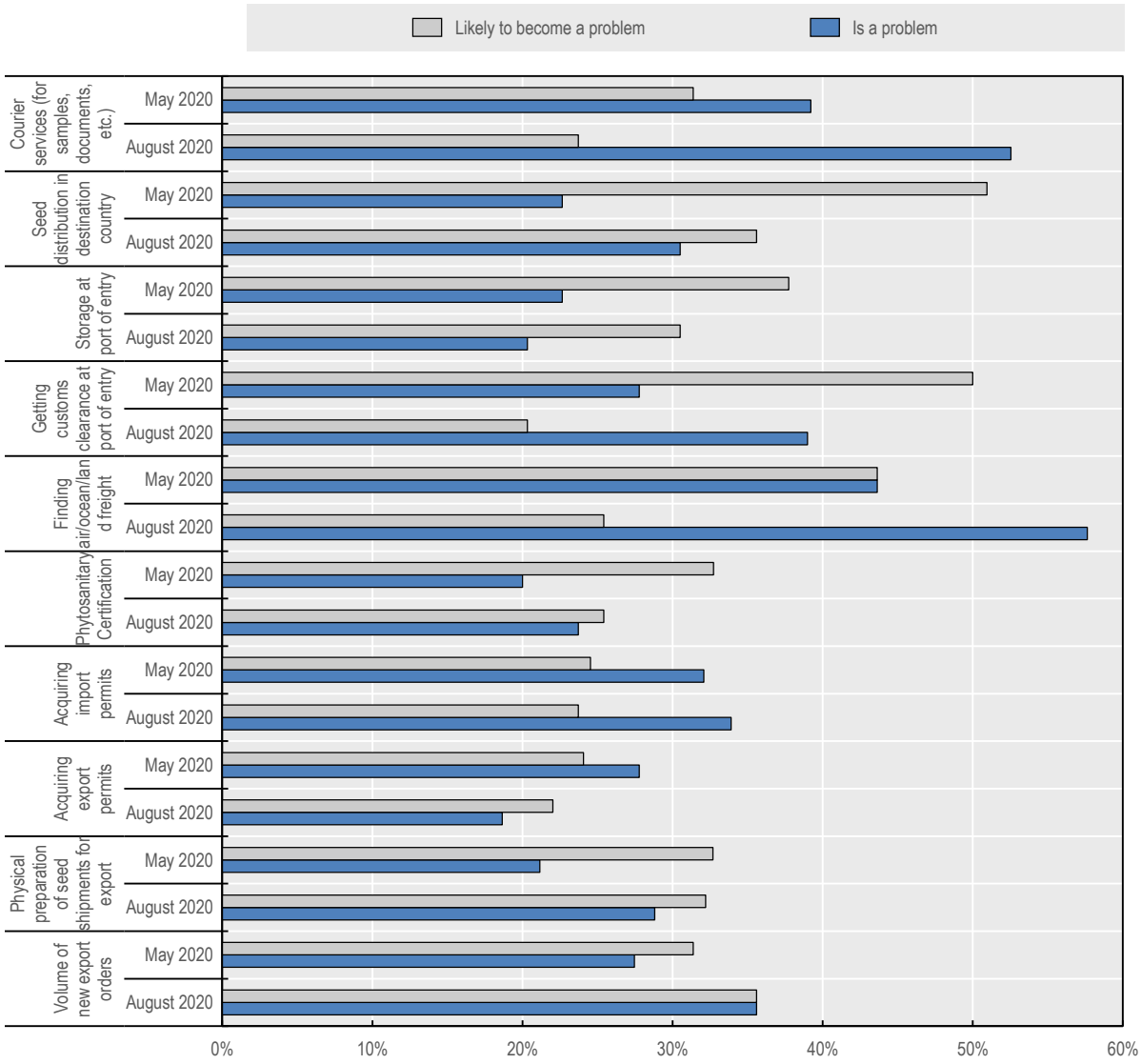



Source: APSA and WorldVeg (2020[36])

The surveys show that seed companies in the Asia Pacific region seem to be more affected by the pandemic than companies in other regions. For example, in the case of vegetable seed demand, around 65% of the seed companies in the Asia Pacific region, as well as outside the region, reported an overall negative effect of pandemic. By August 2020, this had increased for seed companies in the Asia Pacific region to 74%. However, of the 14 seed companies which had their main operations outside the Asia Pacific region, only 38% reported a negative effect on vegetable seed demand in August 2020.

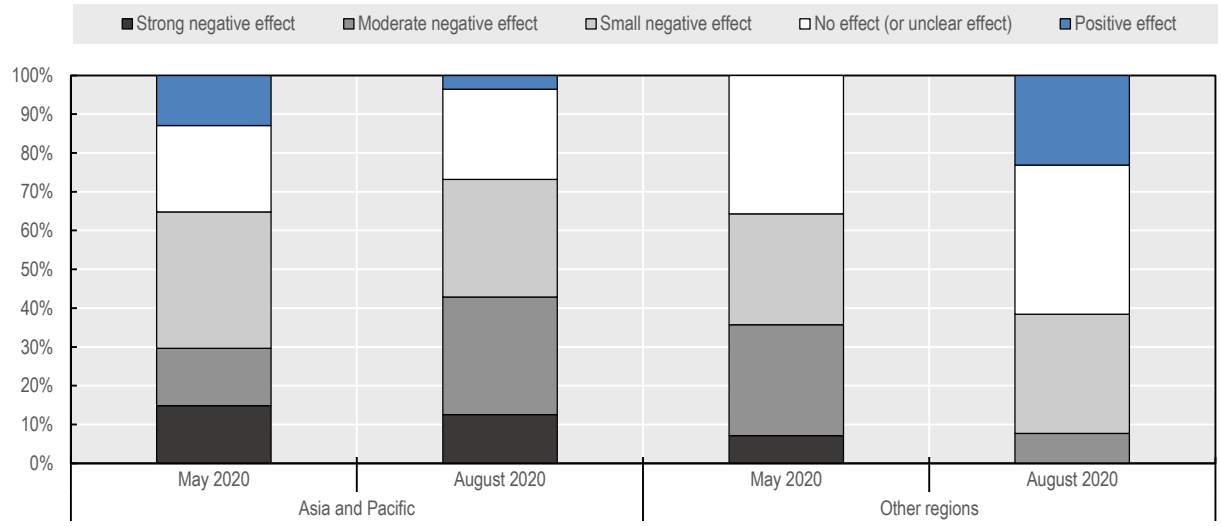
At the global level, ISF confirmed that there was no significant decrease in seed demand. But seed companies with headquarters in the Asia Pacific region experienced a greater decrease in seed demand than their counterparts outside the region. The survey results show that Asian seed companies had more difficulties acquiring the necessary import and export permits, finding the right freight solutions, getting seed storage at the port of entry, and distributing the seed in the destination country.

## Figure 8. Current and expected unusual difficulties and delays in seed companies in the Asia Pacific region (May 2020 vs August 2020)



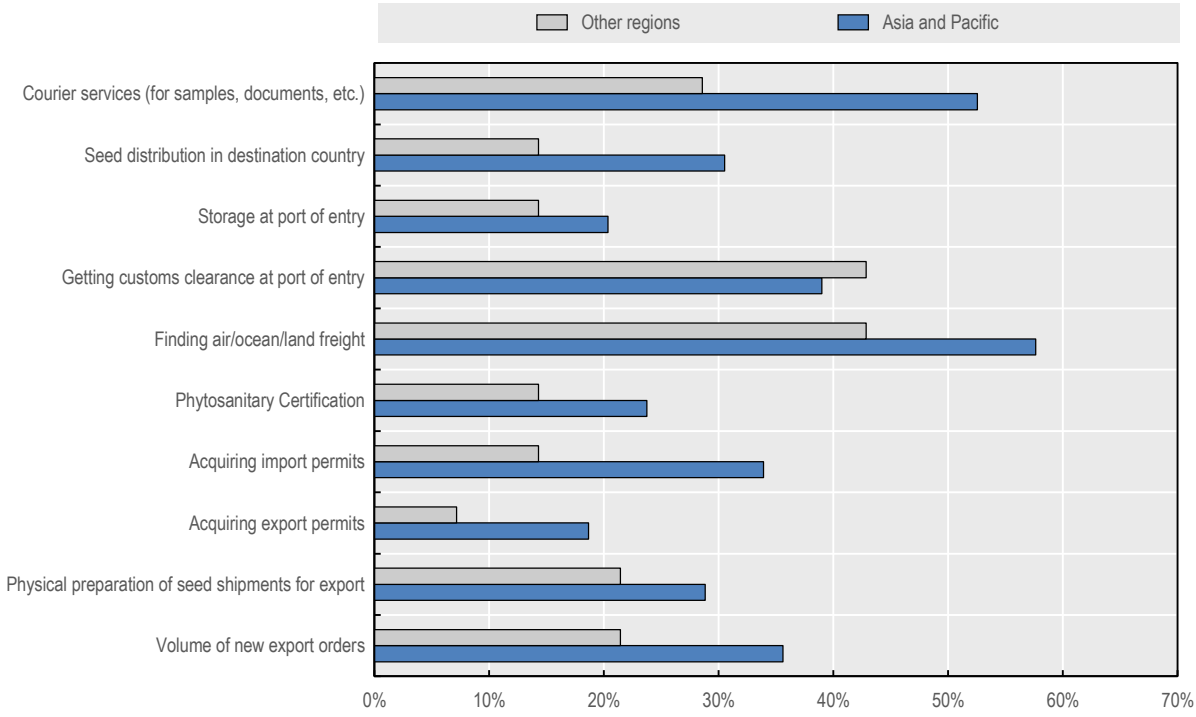

Source: APSA and WorldVeg (2020[36]).

## Figure 9. Impact on vegetable seed demand in May 2020 and August 2020: The Asia Pacific region vs other regions




Source: APSA and WorldVeg (2020[36]).

## Figure 10. Current unusual difficulties and delays for seed companies in August 2020: Asia Pacific region vs other regions




Source: APSA and WorldVeg (2020[36]).

During the height of the pandemic, many of the countries in the Asia Pacific region had imposed stricter international travel bans compared to other regions of the world, which caused or aggravated the problems above and led to the disparity between continents. Seeds of high value crops, such as tomatoes, cucumbers, melon, watermelon and pepper or seeds of parent lines of hybrids, are usually shipped using the spare capacity of passenger planes. So even though cargo planes were often exempted from the travel bans, this did little to mitigate the problem.

At the onset of the pandemic, the home garden sector suffered considerably because of the closure of shops that sell seeds. However, this situation changed when lockdowns were imposed, as people were forced to spend more time at home and started gardening, especially food crops (Walljasper and Polansek, 2020[37]) (Lal, 2020[38]). Several seed companies active in the home garden market experienced an exponential increase in the demand for their home gardening seeds. For example, certain seed companies in the US sold more seed in March 2020 than at any time in their history. In Russia, the demand for seeds rose by 20%-30% year-on-year in March 2020 (Walljasper and Polansek, 2020[37]).

The APSA survey revealed that, of the 59 seed companies from the Asia Pacific region, 56 companies were active in the vegetable seed trade and 28 of these sell small seed packs for home gardens. In this group, 39% reported higher sales of their home garden seed packs (APSA and WorldVeg, 2020[36]). Remarkably, these companies were mostly located in East and Southeast Asia, whereas none of the companies in South Asia reported increasing sales of home garden seed packs. As part of their COVID-19 relief efforts, several seed companies from South and Southeast Asia donated home garden seed packs to the general public.

## 4.3. Survey of Japanese seed companies

In September and October 2020, the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF) conducted two surveys among Japanese seed companies about the impact of COVID-19. Fourteen member companies of the Japan Seed Trade Association (JASTA) responded to the surveys.

As indicated above, Japan is a large importer of seeds and there was a growing concern that the restrictions that were put in place to deal with COVID-19 would limit access to seed in Japan. However, Japanese seed companies indicated in the September 2020 survey that they had not experienced any major obstacles when importing seeds. The companies also reported that they expected no problems in seed supply for the spring planting of 2021, as they have sufficient stocks to cope with unexpected emergencies.

Even though the survey results show there were limited disruptions in Japanese seed supply chains in 2020, MAFF continues to monitor seed distribution and supply. MAFF also continues to advocate in international fora that it is crucial to keep the trade in agricultural input products, such as seeds, fertilizer, and crop protection products as open and unhindered as possible.

One major concern is that it will become difficult to ensure the high quality of seeds in the future if the COVID-19 pandemic continues. It is common practice for Japanese seed companies to send their own staff to regularly check on the quality of seed production fields. However, pandemic-related travel restrictions in production countries has hampered the ability of seed company specialists to carry out on-site instruction, inspection, and quality controls at seed production locations (Box 4).

## 4.4. Potential longer term impacts of COVID-19 on the seed supply chain

During the first year of the crisis, the global seed supply chain proved to be resilient and seed companies adapted their operations to the pandemic. The potential longer term impact of COVID-19 on the seed supply chain will depend on how long restrictive measures are kept in place. Even if restrictions are lifted

before the next sowing season, the seed sector would still experience negative effects in the proceeding months and these effects would become more severe the longer restrictions remain.

Throughout many temperate and subtropical regions in the Northern Hemisphere, March and April are the most critical months for the sowing of spring crops, such as canola, spring wheat, corn, sunflower, soybean, barley, and many open field vegetables. The same holds for the sowing of autumn crops in the Southern Hemisphere. If the restrictive measures were to continue for a longer time, seeds might not be delivered in time for sowing. As a result, farmers would miss their sowing windows, and crops could not be produced. This would lead to food and feed shortages in the second half of 2021.

Reports from several countries indicate that the initial lockdown affected access to seasonal labour and had a considerable impact on farm work during the harvest season.[6] In addition, in countries where access to raw materials (including seeds) was reduced, output was lower, which in turn puts pressure on food prices.

In the survey conducted for this report, seed companies indicated that they had trouble completing the planned field inspections, which are necessary during seed production to guarantee high seed quality (Box 4.). Also, the quantity and intensity of seed testing was impaired. Purity and seed quality problems could lead to higher production costs, a reduction in seed production and eventually even a reduction in sales capacity. If restrictive measures stay in place for a longer period, e.g. well into 2021, then this could lead to increased use of uncertified seed which could affect yields and product quality.

The restrictions imposed by COVID-19 are not only placing constraints on seed production and transportation, but also on the marketing of seed, which can contribute to an increase in seed prices. Rising seed prices means that fewer farmers, especially in developing countries, can afford seed. Reduced access to seed will in turn result in lower food and feed production, reduced income, and could eventually lead to poverty and food shortages.

Several of the surveyed seed companies indicated that they fear a shrinking market and are worried about a slow recovery once restrictions are eased. More specifically, they concern about their competitiveness and expect a decrease in their market share, as well as in their R&D investments. With a shrinking market and transport challenges, companies' may lose part of their production area in temperate and subtropical regions in the Northern Hemisphere. Such adverse impacts are likely to lead to disruptions in the seed industry supply chain.

Other companies have expressed concern that once measures are lifted, it will be more difficult to secure production contracts for the upcoming 2021-2022 season. Some estimate this could reduce company turnover by as much as 20-30%.

The longer-term impacts of COVID-19 on the seed supply chain are difficult to estimate, not only because of the uncertainty of when restrictive measures will be lifted, but also because of a lack of information on seed supply for government officials. Most countries have not invested in implementing more efficient data management and integration, specifically relating to seed production data. This is creating information gaps, which makes it impossible to conduct detailed analyses of the sector.

[6] See for example (Bruins, 2020[49]) (Bruins, 2020[51]) (Bruins, 2020[48]) (Bruins, 2020[50]) (Bruins, 2020[52]) (Bruins, 2020[53]) (Bruins, 2020[54]), which examine the impact COVID-19 on the Seed Sector in Ireland, Italy, Portugal, Spain, Sweden, Switzerland and the Netherlands.

### Box 4. Differences between agricultural and vegetable seed certification

Many countries have established a formal seed sector and require official control and certification of agricultural seed production to guarantee good quality seed for their farmers. This obligation is usually governed by national seed legislation and minimum standards, which are often harmonised with regional or international certification systems such as the OECD Seed Schemes. Agricultural seeds produced in this framework are usually traded as certified seeds, guaranteed by governments. In addition to this compulsory official inspection, seed companies usually control the production and quality of agricultural seed strictly as part of their own quality assurance systems. These private standards can be even higher than the official minimum standards. This dual control system makes the agricultural seed production and quality certification system reasonably resilient, even in a crisis.

However, the situation is different for vegetable seed production and certification. Governments are usually not involved in quality control of vegetable seed production and certification; their role is limited to supervision of the seed producing companies. This control structure was developed historically and is based on the high level of vertical integration in the vegetable seed sector. Seed companies have direct relationships with vegetable growers and have the ability to collect immediate feedback or handle complaints. In the case of agricultural crops, seed travels through complex supply chains of different distributors, so seed companies do not always have direct links with farmers.

This indirect relationship explains why agricultural seed certification is carried out by state authorities as opposed to seed companies themselves. As a result, vegetable seed is usually traded as "standard seed", of which the quality is entirely guaranteed by the seed producer. Although minimum quality standards are still regulated by government, private standards are often higher than official standards.

## 5. Policy considerations

Seeds are a key input for agricultural supply chains. They play a vital role in agricultural and food systems, providing sufficient and nutritious food for the world's population. Access to high-quality seed is crucial to support livelihoods and increase the resilience of farmers and other actors in the value chain (OECD, 2021[8]).

The surveys on the effects of COVID-19 on the Asia Pacific region seed market and on the OECD seed varietal certification system highlighted the two main bottlenecks in the seed supply chain: the availability of staff in the seed production chain and in governmental administration, and the distribution of seed from the production site to farmers. Despite these problems, the seed supply chain has been reasonably resilient to date. However, some governments and stakeholders remain uncertain about future seed availability because of the lack of information on seed supply.

The essential role of seed in the agriculture value chain and experience during the COVID-19 crisis point to the importance of a supportive regulatory environment for the seed supply chain to ensure a sufficient supply of high-quality seed and choice of varieties for farmers in the subsequent growing seasons. Government policies should aim to support diversification of seed production and increase transparency in the seed supply chain to provide more information on seed availability and ensure evidence-based decision making.

The following policy recommendations are based on the outcomes of the COVID-19 surveys among APSA members and in the OECD Seed Schemes, and are intended to help governments develop and facilitate an even more resilient and transparent seed supply chain to mitigate the possible effects of a future crisis.

## 5.1. Ensure production and movement of seed during a crisis

It is crucial for the agricultural sector, which includes the seed sector, to continue to be classified as "essential" in all countries to ensure the continued production and movement of seed during the COVID-19 pandemic and beyond. At the same time, it is important to carefully consider any changes to existing regulatory frameworks (e.g. certification and phytosanitary requirements, customs clearance) and avoid any technical barriers to trade when the relevant authorities are short-staffed, under pressure, and cannot easily adjust to changing requirements. Communication and coordination between governments and authorities is even more important during a crisis to avoid interruptions in the seed supply chain (OECD, 2020[31]).

As a result of the COVID-19 pandemic, the OECD Seed Schemes are in the process of developing Guidelines for Emergency Situations with the goal of sharing best practices among authorities. Maintaining the integrity and reliability of the OECD seed varietal certification system is a priority and participating countries must continue to respect seed standards and certification procedures while adapting to difficult situations. Regular communication with partner authorities can facilitate the production and movement of high-quality certified seed.

## 5.2. Support the development of international seed supply chains and the diversification of seed production

The OECD recently examined global value chains in the context of the COVID-19 crisis (OECD, 2021[39]). This study found that there are considerable benefits to having internationally interconnected value chains for the majority of countries in terms of economic stability and activity. Localised regimes were found to be more vulnerable to shocks. The study also illustrates that there are benefits associated with using government policies to make international supply chains more resilient. As most countries cannot sufficiently supply their farmers with seeds of their choice solely from their own national seed production (ISF, 2020[40]), the economic risks of localising seed production would be higher than maintaining international seed supply chains and developing policies to mitigate the associated risks.

Diversification of seed production has been part of the business model and risk management plans of seed companies for many years. Companies spread their seed production across countries and regions in order to benefit from optimal growing conditions, enable year-round harvesting, make use of local expertise and mitigate the risks of adverse weather conditions and climate change. This practice can lead to improved seed supply management and possibly reduce seed production costs. The diversification enables seed companies to continuously supply farmers with high-quality seed. This diversification also helps seed companies to reduce the impact of local disruptions in seed production due to COVID-19 and makes the seed supply chain more resilient during a crisis.

Governments can support the resilience of international seed supply chains and the diversification of seed production by maintaining and further enhancing the enabling international regulatory framework for seed production and trade. The regulatory framework ensures the genetic integrity and health of seed during the various seed production steps, and facilitates the exchange of seed between countries by preventing non-tariff barriers. It also ensures the protection of plant breeders' rights in seed producing countries which encourages breeders to allow multiplication of their varieties in multiple locations around the world. This international regulatory framework is developed and implemented by various international organisations such as the OECD Seed Schemes, FAO, ISTA and UPOV. Active membership in these organisations is

encouraged to further harmonise and develop seed quality standards and certification procedures, as well as the protection of plant breeders' rights.

Diversification of seed production can also be facilitated by supporting developing countries to develop their national seed sectors in line with international seed regulatory frameworks. Many countries depend on trade as a driver of economic growth. As such, harmonising seed standards increases a country's potential to participate in the international seed supply chain as a seed producing country but also by enabling their farmers to access high- quality seed of modern varieties, delivering both local and global benefits. This has implications for food security as well as incomes for seed-producing farmers and breeders.

The OECD Seed Schemes have developed a capacity building strategy to help countries develop and harmonise their national seed certification system with OECD seed standards and certification methods to facilitate their accession to the Schemes and participate in the international seed supply chain. The costs of such capacity building activities are usually covered by the requesting country but can also be covered by a third party.

## 5.3. Support digitalisation of the seed supply chain

A recent OECD report (OECD, 2020[41]) noted that the COVID-19 crisis accelerated some pre-existing trends, in particular digitalisation. While some countries stepped up their digitalisation, the report also warns that the existing digital divide could increase as not all governments have the capacity to implement the digital transition in the short and medium term (OECD, 2020[41]). UNCTAD (UNCTAD, 2020[42]) has also seen that the pandemic is driving digitalisation but that this digitalisation has been uneven both across and within countries.

The survey of Seed Schemes participating countries (OECD, 2020[34]) showed that countries with a higher level of digitalisation of their seed certification process were more resilient during the crisis. Seed production and certification processes were supported by digital tools that reduced the impact of disruptions to staffing and travel. For example, authorities were able to issue certificates digitally without making companies wait for the delayed hard copies.

Inter-governmental digitalisation initiatives may reduce digitalisation inequalities between countries by providing a wide range of users with access to digital platforms. Increasing the digitalisation of certain procedures in the seed supply chain, such as seed or phytosanitary certification, and creating more open data policies would be a proactive step forward for policymakers to support more resilient seed systems.

The OECD Seed Schemes is in the process of digitalising its certification system. Although a number of countries have already digitalised their national certification systems, the goal is now to connect national systems via an international database (Box 5). Apart from increasing the speed and efficiency of certification processes, digitalisation would also facilitate data collection, reporting and analysis and provide greater transparency over seed trade to support better policy making.

Digitalisation also has an important role in the recovery of the private seed sector from the negative effects of the pandemic as it has the potential to increase efficiency and reduce seed production costs. Participants at APSA's 6th Expert Consultation on Phytosanitary Collaboration in the Asia Pacific region recognised that harmonised standards and digital tools are crucial to make the seed supply chain more resilient. One of the outcomes of the meeting was overwhelming support among industry representatives and officers of National Plant Protection Organizations (NPPOs) for the need "to implement electronic phytosanitary certification systems (ePhyto), utilize third-party lab-testing accreditation models, and adopt a Systems Approach with regard to ISPM 38 on the international movement of seed" (APSA, 2020[43]).

### Box 5. Digitalisation of the OECD Seed Schemes

The OECD Seed Schemes has been exploring ways to improve the efficiency and integrity of its certification and labelling system. As participation in the Seed Schemes has increased, the volume of seed being traded has grown and so has the risk of fraud. As such, the Schemes are looking for tools and technologies that would make labelling and certification more robust and reliable.

In addition, the Schemes want to improve data collection and provide governments and other supply chain stakeholders with more accurate and up-to-date information on the production, certification, and international trade of seed. Digitalisation presents a solution to both these challenges. Furthermore, the COVID-19 pandemic has highlighted the important role digitalisation could play in mitigating the impacts of staffing and transport disruptions.

Since June 2020, the OECD Seed Schemes Secretariat has been working with an expert consultant to develop a feasibility study and digitalisation strategy for the OECD Seed Schemes. The study is evaluating the financial and operational viability of a range of digital tools and suggests a path forward. The final step will be the development of a pilot project.

## 5.4. Ensure public availability of information on seed production and the supply chain

The current pandemic also highlighted that there is insufficient information publicly available on seed stocks, trade and production, which would allow governments to react quickly to disruptions in the seed supply chain. It is particularly a problem in those countries where farmers did not develop robust information networks for input supplies. Governments should take a proactive approach and coordinate their efforts to prepare for a future pandemic or for regional or global crises. Such a coordinated response should include generating and sharing real-time data and implementing early warning systems, which would enable them to provide technical expertise and necessary support when and where it is needed most.

This international coordination already exists in the food sector. The Agricultural Market Information System (AMIS) is an inter-agency platform established in 2011 by the G20 Ministers of Agriculture in response to the global food price hikes in 2007/08 and 2010 (AMIS, 2021[44]). AMIS aims to enhance food market transparency and policy responses for food security by bringing together the principal agricultural trading countries and assessing global food supplies with a particular focus on wheat, maize, rice and soybeans. AMIS also provides a platform to coordinate policy action in times of market uncertainty. The AMIS Secretariat is formed by the following ten international organizations and entities: FAO, GEOGLAM, IFPRI, IFAD, IGC, OECD, UNCTAD, the World Bank Group, WFP, and WTO.

That said, the seed supply chain has several characteristics which would make it difficult to set up a market information system similar to AMIS. Seed stock information is usually not publicly accessible but privately held by seed companies. In addition, seed of a variety of an agricultural species is not necessarily replaceable with seed of another variety of the same species. Varieties are developed for specific purposes and adapted to different climatic conditions. In addition, some countries and regions do not accept certain varieties because of their specific characteristics.

A more realistic approach would therefore be to collect information and trace ongoing seed production in different countries and share this information on an international platform. Currently such a platform is not available. However, the OECD Seed Schemes is currently working on the digitalisation of its varietal certification system, including the development of a database of ongoing seed certification activities (Section 5.2 and Box 4). Once this system is developed, it has the potential to be the basis of an international data sharing platform of ongoing seed production in participating countries.

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# Annex A. Seed trade

## Table A A.1. Top 10 Major seed exporting countries in the world (2018) – Quantity in metric tonnes

| Country | Vegetable crops | Field Crops | Total |
|---|---|---|---|
| France | 9 124 | 601 796 | 610 920 |
| United States | 13 209 | 467 877 | 481 086 |
| Poland | 643 | 261 941 | 262 584 |
| Canada | 113 | 190 665 | 190 778 |
| Hungary | 1 860 | 186 815 | 188 675 |
| Czech Republic | 321 | 188 236 | 188 557 |
| Netherlands | 13 249 | 137 654 | 150 903 |
| Romania | 95 | 148 410 | 148 505 |
| Denmark | 11 233 | 134 220 | 145 453 |
| Germany | 1305 | 137 038 | 138 343 |

Source: ISF (2018[20]).

## Table A A.2. Top 10 Major seed exporting countries in Asia (2018) – Quantity in metric tonnes

| Country | Vegetable crops | Field crops | Total |
|---|---|---|---|
| India | 10 420 | 26 754 | 37 174 |
| New Zealand | 6 445 | 22 310 | 28 755 |
| China | 4 100 | 21 500 | 25 600 |
| Australia | 3 421 | 14 000 | 17 421 |
| Japan | 845 | 9 100 | 9 945 |
| Indonesia | 3 311 | 4 069 | 7 380 |
| Viet Nam | | 6 000 | 6 000 |
| Korea | 568 | 5 000 | 5 568 |
| Thailand | 2 609 | | 2 609 |
| Hong Kong China | 2 401 | | 2 401 |

Source: ISF (2018[20]).

## Table A A.3. Top 10 Major seed exporting countries in the world (2018) – Value in Million USD

| Country | Vegetable crops | Field crops | Total |
|---|---|---|---|
| Netherlands | 1 868 | 333 | 2 201 |
| France | 485 | 1 366 | 1 851 |
| United States | 599 | 1 232 | 1 831 |
| Germany | 81 | 765 | 846 |
| Hungary | 11 | 442 | 453 |
| Denmark | 67 | 335 | 402 |
| Italy | 124 | 242 | 366 |
| Romania | 2 | 315 | 317 |
| Austria | 1 | 309 | 310 |
| Chile | 185 | 123 | 308 |

Source: ISF (2018[20]).

## Table A A.4. Top 10 Major seed exporting countries in Asia (2018) – Value in Millions USD

| Country | Vegetable crops | Field crops | Total |
|---|---|---|---|
| China | 120 | 69 | 189 |
| New Zealand | 51 | 84 | 135 |
| Thailand | 108 | 25 | 133 |
| India | 96 | 37 | 133 |
| Japan | 77 | 46 | 123 |
| Australia | 28 | 90 | 118 |
| Korea, Rep | 50 | 15 | 65 |
| Hong Kong, China | 56 | | 56 |
| Indonesia | 10 | 10 | 20 |
| Viet Nam | | 18 | 18 |

Source: ISF (2018[20]).

## Table A A.5. Top 10 Major seed importing countries in the world (2018) – Quantity in Metric tonnes

| Country | Vegetable crops | Field crops | Total |
|---|---|---|---|
| Belgium | 7 989 | 648 688 | 656 677 |
| Netherlands | 14 093 | 586 097 | 600 190 |
| Italy | 5 031 | 338 847 | 343 878 |
| Germany | 3 281 | 263 038 | 266 319 |
| Spain | 3 845 | 254 930 | 258 775 |
| United States | 11 038 | 210 665 | 221 703 |
| France | 5 633 | 152 271 | 157 904 |
| Poland | 1 653 | 151 696 | 153 349 |
| United Kingdom | 3 147 | 117 650 | 120 797 |
| Greece | 2 266 | 98 878 | 101 144 |

Source: ISF (2018[20]).

## Table A A.6. Top 10 Major seed importing countries in Asia (2018) – Quantity in Metric tonnes

| Country | Vegetable crops | Field crops | Total |
|---|---|---|---|
| Japan | 4 925 | 66 656 | 71 581 |
| Viet Nam | | 49 600 | 49 600 |
| Australia | 1 200 | 31 980 | 33 180 |
| India | 7 586 | 25 112 | 32 698 |
| Indonesia | 473 | 27 300 | 27 773 |
| Malaysia | 1 260 | 7 660 | 8 920 |
| China | 8 711 | | 8 711 |
| New Zealand | 328 | 5 654 | 5 982 |
| Pakistan | 4 143 | | 4 143 |
| Singapore | 1 | 3 000 | 3 001 |

Source: ISF (2018[20]).

## Table A A.7. Top 10 Major seed importing countries in the world (2018) – Value in Million USD

| Country | Vegetable crops | Field crops | Total |
|---|---|---|---|
| Netherlands | 570 | 525 | 1,095 |
| United States | 400 | 596 | 996 |
| France | 379 | 599 | 978 |
| Germany | 141 | 542 | 683 |
| Spain | 345 | 248 | 593 |
| Italy | 235 | 301 | 536 |
| Mexico | 379 | 127 | 506 |
| Russia | 80 | 350 | 430 |
| China | 227 | 145 | 372 |
| Belgium | 40 | 292 | 332 |

Source: ISF (2018[20]).

## Table A A.8 Top 10 Major seed importing countries in Asia (2018) – Value in Millions USD

| Country | Vegetable crops | Field crops | Total |
|---|---|---|---|
| China | 227 | 145 | 372 |
| Japan | 154 | 120 | 274 |
| Australia | 68 | 61 | 129 |
| India | 90 | 37 | 127 |
| Korea | 75 | 38 | 113 |
| Pakistan | 46 | 38 | 84 |
| New Zealand | 18 | 33 | 51 |
| Hong Kong, China | 49 | | 49 |
| Viet Nam | 12 | 35 | 47 |
| Thailand | 25 | 21 | 46 |

Source: ISF (2018[20]).

# Annex B. Vegetable production in Asia

## Table A B.1. Production of main vegetable groups in selected Asian countries in 2018 (thousand tonnes)

| | China | India | Indonesia | Japan | Korea | Thailand | Viet Nam | Asia |
|---|---|---|---|---|---|---|---|---|
| Artichokes | 90 | | | | | | | 166 |
| Asparagus | 7984 | | | 27 | | 24 | | 8059 |
| Beans, green | 19909 | 715 | 940 | | | 315 | | 22924 |
| Cabbages & other Brassicas | 33840 | 9035 | 1408 | 1379 | 2537 | 264 | 873 | 54008 |
| Carrots & Turnips | 18018 | 583 | 637 | 612 | 75 | 14 | | 25392 |
| Cauliflowers & Broccoli | 10737 | 8800 | 152 | 164 | 0.07 | | 140 | 21108 |
| Chillies & peppers, green | 18214 | 80 | 2542 | 140 | 230 | 19 | | 24991 |
| Cucumbers & gherkins | 56293 | 196 | 434 | 550 | 333 | 151 | | 65619 |
| Eggplants (aubergines) | 34137 | 12826 | 552 | 300 | 5 | 20 | | 50629 |
| Garlic | 22334 | 1721 | 39 | 21 | 331 | 74 | | 26059 |
| Leeks & other alliums | 156 | | 573 | | 153 | | | 1314 |
| Lettuce & chicory | 15546 | 1223 | | 578 | 85 | 31 | | 18891 |
| Maize, green | 106 | | 590 | 223 | | 305 | | 1311 |
| Mushrooms & truffles | 6675 | 61 | 31 | 66 | 23 | 1 | 24 | 7032 |
| Okra | | 6126 | | | | | | 6509 |
| Onions, dry | 24775 | 22071 | 1503 | 1155 | 1521 | 31 | 401 | 65320 |
| Onions, shallots, green | 1063 | | | 530 | 468 | 131 | | 2535 |
| Peas, green | 12965 | 5430 | | 28 | | 4 | | 18781 |
| Pumpkins, squash & gourds | 8186 | 5570 | 454 | 197 | 322 | 121 | | 17133 |
| Spinach | 23805 | | 162 | 226 | 68 | | | 24855 |
| String beans | 11 | | | 38 | | | | 277 |
| Tomatoes | 61631 | 19377 | 977 | 724 | 345 | 109 | | 111684 |
| Vegetables fresh NES | 174861 | 34430 | 516 | 2720 | 3301 | 1092 | 14880 | 257954 |
| Vegetables Leguminous NES | 209 | | | 15 | | 2 | | 434 |
| Total Vegetables Primary | 551556 | 128243 | 11510 | 9697 | 9798 | 2709 | 16317 | 832985 |

NES = Not elsewhere specified / top three groups have been underlined
Source: FAOSTAT (FAO, 2021[28]).

## OECD FOOD, AGRICULTURE AND FISHERIES PAPERS

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Comments are welcome and can be sent to tad.contact@oecd.org.