Challenges and Perspectives in Global Rapeseed Production

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EXECUTIVE SUMMARY

Following the significant expansion of rapeseed production across Europe (EU28) beginning in the 1980s, the area of land utilised for growing rapeseed has peaked and is now on the decline in a number of the major Western European producing nations.

As part of initiatives outlined by the International Rapeseed Congress 2019, held in Berlin, the Thünen Institute of Farm Economics and the *agri benchmark* network brought together a panel of experts from major rapeseed producing countries (Australia, Canada, France, Germany, Poland and the UK). These experts demonstrate expertise in farm economics, agronomy, crop care, pest and disease, crop breeding and rapeseed production, to gather their insights on the challenges facing rapeseed production, along with what can be done to combat them.

This paper consolidates the insights of those experts, as well as a follow-up study on the farm-level economic impact of the challenges faced by the rapeseed industry. Furthermore, the implications of implementing management strategies to combat these challenges are also discussed.

In many of the top producing countries, yield levels have stagnated or even decreased in the past few years, with more extreme climatic conditions, especially during crop establishment, and increased pest burden, seen as the main factors. This, along with increasing limitations on crop care treatments, are becoming a greater concern due to both policy changes and insecticide resistance issues.

The panel of experts all agreed that tight rotations, where rapeseed was grown one year in three, or even two in some instances, has been a large part of the reason for the increased pressure within the sector.

France, where rotations have historically been wider and more diverse, does not appear to have quite the same levels of pest and disease issue, despite having similar natural conditions, and neighbouring other high producing countries.

Across Europe, experts tend to expect that fertiliser application levels will need to be reduced, whilst crop care costs will increase, despite an expected stagnation in yield levels. This is in contrast to Australia and Canada who expect yield gains as a result of improved varieties and increased fertiliser usage.

Following the neonics ban in 2016, both wingless and winged insects, have increased in most hotspot regions for rapeseed production in Europe, and in some cases, are now at levels that make rapeseed production economically unviable. This is particularly true for the cabbage stem flea beetle in the UK and parts of northern Germany

Along with increased insect prevalence, greater incidence of diseases has also been reported. Clubroot and Sclerotinia are becoming particularly widespread issues.

Use of chemicals in crop care management remains under regulatory pressure with threats that the remaining chemical options could soon be reduced even further. In many instances, this would mean that European producers have to look to more fundamental shifts in their management practices and production systems.

In Australia and Canada, current chemical options and potential genetically modified (GM) variety development technologies give producers a wider suite of management options. However, insecticide resistance issues are a growing trend, and pressure from environmental lobbies mean that there are regulatory threats to the long-term future of neonic pesticides, particularly in Canada. This could be

very damaging to Canadian rapeseed production given the popularity of the crop and the tight rotations that farmers employ.

With profit margins in rapeseed facing significant constraints in Europe, and the introduction of wider rotations now serving as a necessary management tool, the search for economically-competitive alternative break-crops is taking centre stage.

In Europe, few other widescale broadleaf crops, such as field beans and peas, can match the historical performance of rapeseed; even now, at lower economic performance levels of rapeseed, they compare unfavourably in economic terms. In the right conditions, lupins can compete favourably, but the market is too small and volatile to offer an alternative at scale. In southeast Europe, there are also options to grow soybeans and/or sunflowers, but this growing area was not part of our workshop, and only a small crossover with rapeseed producing regions in any case.

The result is that with the agronomic need to move away from growing the high quantities of rapeseed that were previously necessary, farm profits are likely to decrease. The scenario analysis used in this investigation determined that this could mean losses of €100 – €150 /ha throughout the region. Continuing to cultivate rapeseed in tight rotations is not, however, an option as the potential losses from pest and disease would be unviable.

As part of the workshop session, the panel of experts discussed recommendations to combat challenges in rapeseed production, including suggestions for policy makers, rapeseed unions and areas for further investigation and research. The following details the recommendations as determined by the expert panel:

(1) Undertake a large-scale study into the survival and re-infestation rates of insects, by zoning an area which has implemented a pause in rapeseed production for a period of years.
(2) Determine which natural defences exist in the environment, particularly the beneficial predator insects that naturally occur in the wild, as well as the habitats they require to survive.
(3) Procedures related to the assessment and identification of pests and diseases should be improved and standardized to give growers the right advice at the right time, both agronomically and economically. Digital platforms have a role to play in this and should also be reviewed within this context.
(4) The misuse of pesticides was a considerable contributing factor for insecticide resistance issues; thus, a levy system to discourage misuse should be considered.
(5) Finally, all participants agreed that the joint global approach developed by this group of experts should be used as a model to foster exchange among stakeholders from all areas of rapeseed research and the value chain. A global division of labour can help to generate solutions to the challenges growers face and thereby strengthen global rapeseed production as a profitable and sustainable element of modern crop production.

1. INTRODUCTION & ACKNOWLEDGEMENTS

Following the significant expansion of rapeseed production across Europe beginning in the 1980s and continuing through the 2000, the area of land utilised for growing rapeseed is now being reduced in a number of high producing Western European nations.

In many of these countries, yield levels have stagnated or even declined in recent years as policy changes have restricted certain active ingredients previously used in crop care treatments. This has been identified as a key reason for a build-up in pest prevalence and resistance issues, which has ultimately resulted in poor yield performance when compared to historical averages.

These difficulties have led to the economic benefits and competitive advantage that rapeseed had previously enjoyed over other broadleaf break-crops, and even some cereals within the winter cereal-dominated rotations of Europe, not being as strong as it once was.

Evidence over recent years suggests that producers are now reducing the amount of land they use for growing rapeseed, or in extreme cases, even moving away from rapeseed production altogether.

A workshop was therefore convened at the International Rapeseed Congress (IRC) 2019 in Berlin, hosted by the Thünen Institute of Farm Economics and the *agri benchmark* network , bringing together a panel of experts from across a number of key rapeseed producing countries in Europe, as well as major players Australia and Canada, to discuss the issues facing rapeseed production. The panel included experts in the areas of farm economics, agronomy, crop care, pest and disease, crop breeding and rapeseed production.

The purpose of the workshop, along with the wider study, was to gather global insights into rapeseed production, including critical challenges. Further, an effort was made to delve deeper into understanding how these challenges come about and what can be done to combat them. Prior to the session, participants were asked to complete a questionnaire (see Annex 1) that sought to identify the key pest constraints being experienced in each of the represented countries, the level of intensity of the issues, and the impact they are having on rapeseed production. Participants were further asked to comment on the currently available treatment options, as well as what changes they believed would be likely in the coming years.

The results of the questionnaires were compiled by *agri benchmark*, with the results being discussed and debated by the participants during the workshop.

The discussions resulted in the establishment of a number of recommendations for strategies that could alleviate the aforementioned pressures and, in turn, help to improve the economic performance of rapeseed.

This paper introduces and examines the opinions given by the expert panel as taken from the questionnaire, with the discussions and results emanating from the workshop itself and the follow-up study. We would like to extend our thanks and acknowledgement to our panel of experts who provided insight and participated in the workshop; participants are as follows:

Jackie Bucat (Australia)	Research Scientist, Grains - Research Development and Innovation, Department of Primary Industries and Regional Development, Government of Western Australia
Clint Jurke (Canada)	Agronomy Director, Canola Council of Canada
Stéphane Cadoux (France)	Crop systems studies manager, Terres Inovia

Francis Flénet (France)	Head of AGRO Department, Terres Inovia
Stephan Arens (Germany)	Chief Executive Officer, UFOP
Martin Frauen (Germany)	Plant Breeding Expert, Norddeutsche Pflanzenzucht Hans-Georg Lembke KG (NPZ)
Gerrit Hogrefe (Germany)	Consultant, NU Agrar GmbH
Folkhard Isermeyer (Germany)	President of the Johann Heinrich von Thünen Institute (Chairman of workshop)
Andreas von Tiedemann (Germany)	Head of the division, Plant Pathology and Crop Protection, Department of Crop Sciences, Georg-August-University Göttingen
Bernd Ulber (Germany)	Department of Crop Sciences Plant Pathology and Crop Protection Div. Entomology, Georg-August-University Göttingen
Paweł Boczar (Poland)	Department of Economics and Economic Policy in Agribusiness, Poznan University of Life Science
Yelto Zimmer (Germany)	Head of *agri benchmark* Cash Crop
Tom Arthey (UK)	project coordinator, *agri benchmark*

Although not present at the workshop, thanks also goes to the following for their expert input into the pre-workshop questionnaire and/or in the follow up study:

Dennis Dey (Canada)	Independent Agricultural Economist
Yannick Carel (France)	Economics and Production Systems, Arvalis Institut du Vegetal
Detlev Dölger (Germany)	Managing Director Hanse-Agro
Benjamin Lang (UK)	Senior Research Associate / Manager, Rural Business Unit (RBU), Department of Land Economy, University of Cambridge
Samuel and Madeline Vaughan (UK)	Independent agronomists and rapeseed producers, J & M J Vaughan

The first section of this paper provides a summary of the key features of rapeseed production in each of the represented countries, including the evolution of acreage and yields over the past 10 years.

Using *agri benchmark* data, a comparative analysis of the respective performance of rapeseed in each of the studied countries was undertaken in an effort to understand where the major pressure points currently lay for each country.

Insights are further provided relating to the pest and disease obstacles being experienced in each country and the availability of crop protection products.

Using the data collected from each participant, a summary of likely changes in production systems is then analysed for each country, with a modelled scenario of possible future changes being undertaken to further understand the impact that these issues could have both on rapeseed performance and on the farm as a whole.

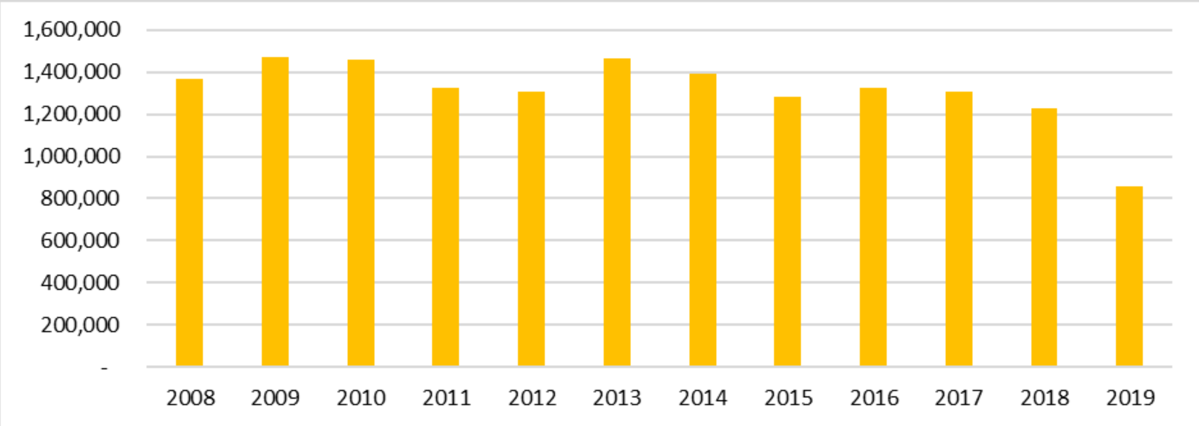
2. COUNTRY INTRODUCTIONS

2.1 Germany

Rapeseed is a very popular break-crop in winter cereal-dominated rotations in Germany, especially in the north-western and central regions of the country. Hot spot regions for production include Schleswig-Holstein, Mecklenburg-Vorpommern, Niedersachsen, Sachsen-Anhalt and Thüringen, although the crop is also grown in many other parts of the country as well.

The land area used for growing rapeseed peaked at approximately 1.47 million hectares between 2009 and 2013, but has been in decline since that time, with approximately 1.23 million hectares planted in 2018. Furthermore, reports suggest a significant drop with only 856,800 ha in 2019.

Figure 1 – Evolution of Rapeseed Area in Germany (ha)

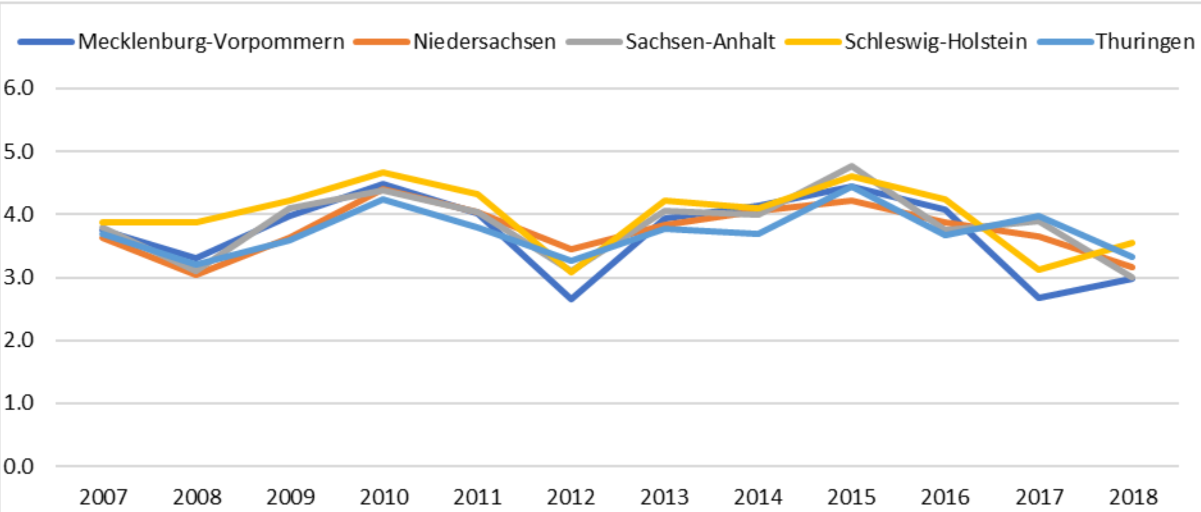


Source: FAOStat

Rapeseed previously occupied a 30 – 40% share of the cropped area on many northern German farms, being grown every 3 to 4 years in rotation with winter cereal crops. In some instances, however, rapeseed has been grown once every two years, in very tight rotations with winter wheat.

Typical cultivation practices for rapeseed in Germany are conservation or intensive tillage-based systems, with winter varieties typically being planted in August.

Figure 2 – Evolution of Yields in Key Production Regions in Germany (t/ha)



Source: KTBL

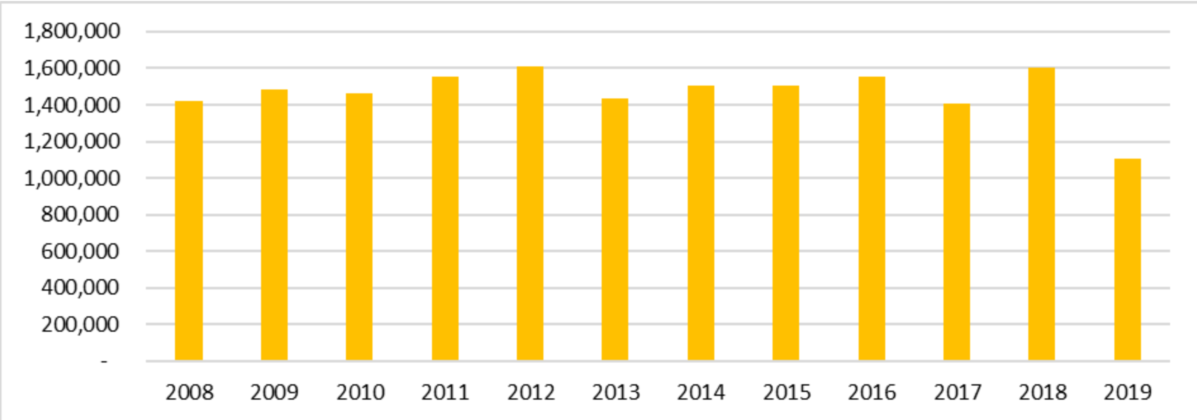
Yield levels are approximately 3.7 t/ha on average, but have stagnated in recent years and are now even in decline in some parts of Germany. This is largely attributed to increased pest prevalence and limitations on the chemical treatment options available, owing primarily to the neonicotinoids ban throughout the EU in 2015. It is important to keep in mind, however, that yields were also negatively impacted by extremely dry weather conditions in 2018 and 2019.

Growing pest issues and the prospect of lower yields has also been attributed to a decline in the cultivated area of rapeseed in Germany, due to the availability of other economically attractive crops, especially those that serve as break-crops in the heavily grain-based system.

2.2 France

France has the largest planted area of rapeseed of any country within the EU, having seen a sharp expansion in acreage throughout the 1990s and early 2000s. The harvested area in France has been relatively stable in the 2010s, with planting averaging between 1.4 – 1.6 million hectares annually. Figures for 2019 show a severe decline, suggesting a particularly challenging year.

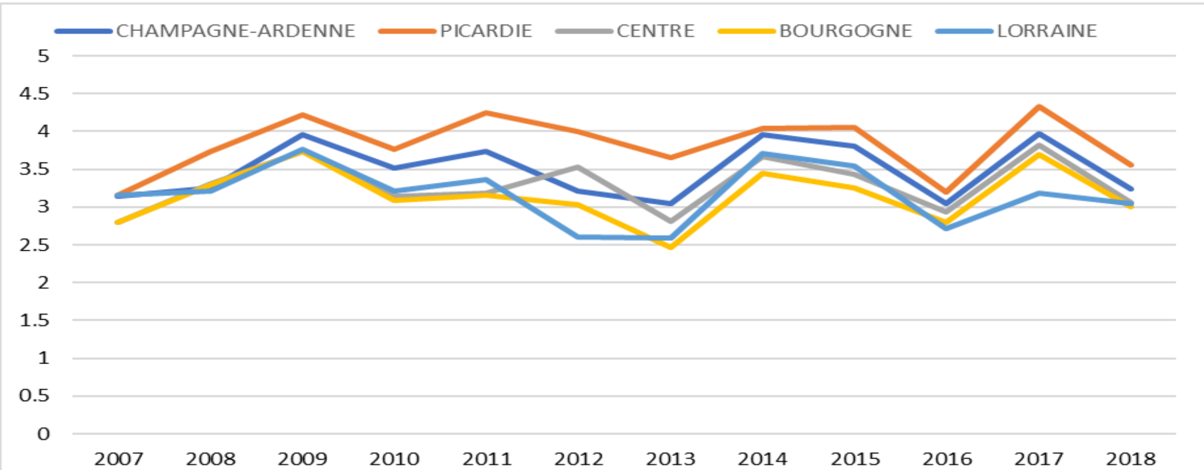
Figure 3 – Evolution of Rapeseed Area in France (ha)



Source: FAOStat

The hotspot regions for rapeseed production are in the northern, central and eastern regions of France, where the crop is grown as a break-crop in combination with winter cereals. Rapeseed typically has a quarter share of the cropped area on farms, up to a third share in the central and eastern areas.

Figure 4 – Evolution of Yields in Key Production Regions in France (t/ha)



Source: AGRESTE - Statistique Agricole Annuelle

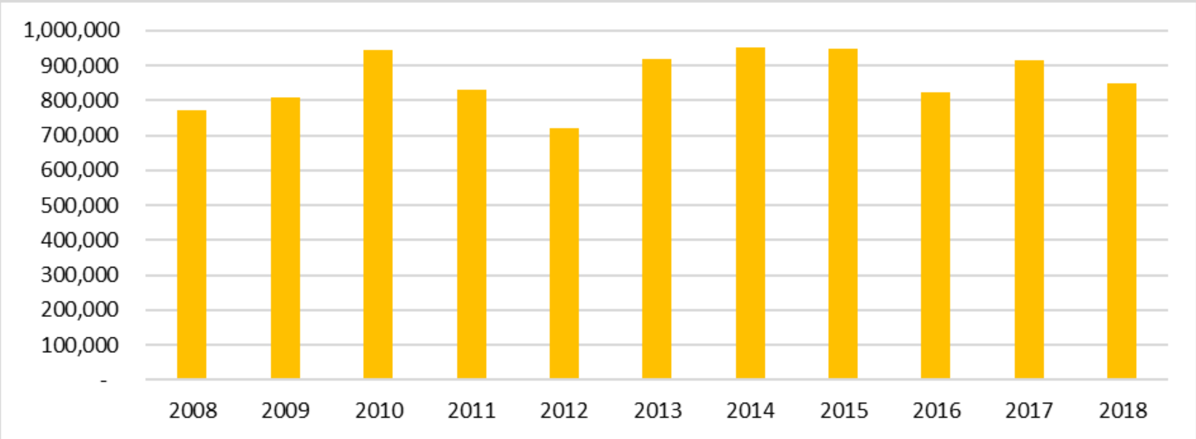
Average rapeseed yields in France are slightly lower than in neighbouring Germany, averaging 3.5 t/ha, and experience considerable regional variability with, for example, 2.7 t/ha in southwest France and 4.3 t/ha in northern areas.

The tillage systems commonly used in French rapeseed production include deep ploughing (particularly in northern regions) and conservation tillage practices.

2.3 Poland

Rapeseed has traditionally been quite a challenging crop to grow in Poland due to climatic conditions and winter kill risk, especially when snow cover is insufficient. Despite these challenges, however, the annual planted and harvested area has risen significantly since the 1980s, with 800,000 – 900,000 ha harvested annually over the past 5 years.

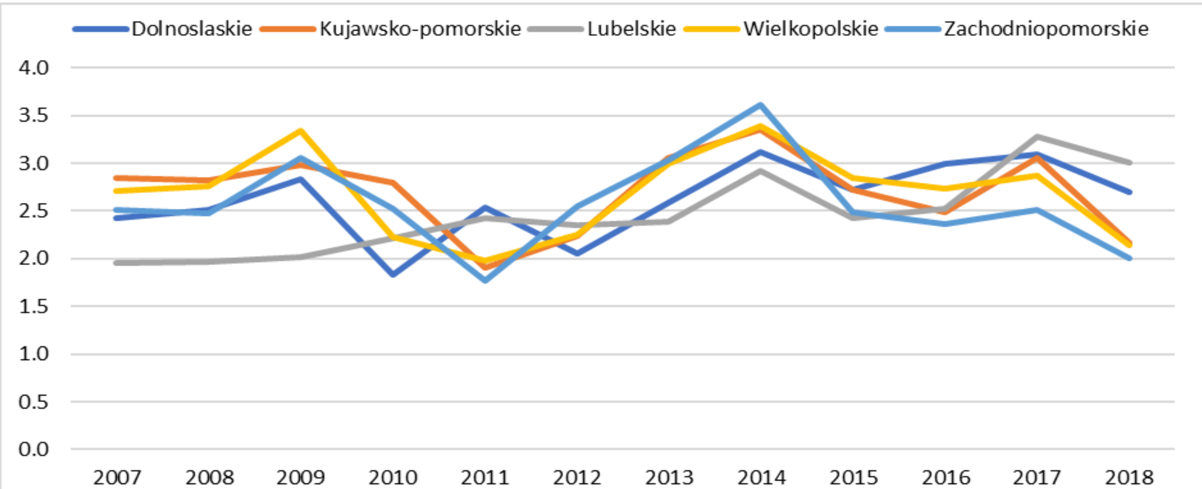
Figure 5 - Evolution of Rapeseed Area in Poland (ha)



Source: FAOStat

The hotspot production regions are in central and western Poland, with Zachodniopomorskie, Wielkopolskie, Kujawsko-Pomorskie, Dolnośląskie and Opolskie voivodeships being noted as particularly relevant areas of production; rapeseed is, however, grown in other parts of the country as well. Typically, cultivation occurs in rotation with winter and spring cereals and typically occupied approximately 30% of a farm’s cropped area in the past, yet this figure has reduced to approximately 25% in recent years.

Figure 6 - Evolution of Yields in Key Production Regions in Poland (t/ha)



Source: Statistics Poland

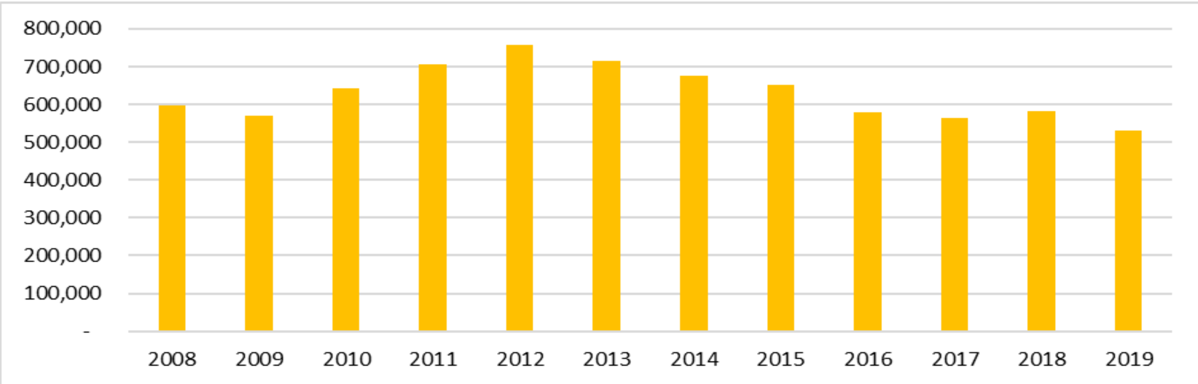
The average country yield is currently 2.8 t/ha, but in the aforementioned hot spot regions, yields of 3 – 3.5 t/ha are commonly reached. Further yield improvement remains possible in some regions through variety selection and technological improvements that could see yields regularly exceed 4 t/ha.

Cultivation practices in Poland centre around ploughing, mulching and strip tillage. There are no expectations for large-scale shifts in the commonly used tillage systems of farmers in the near future.

2.4 United Kingdom

Rapeseed has also been a key break-crop within winter cereal-dominated rotations over the past 30 years in the United Kingdom. The area harvested for rapeseed peaked at 756,000 ha in 2012, but has faced a steadily downward production trend since that time, with the harvested area in 2019 estimated at 529,000 ha. Estimates for the 2019/20 season suggest that 406,000 ha will be harvested in 2020 (AHDB).

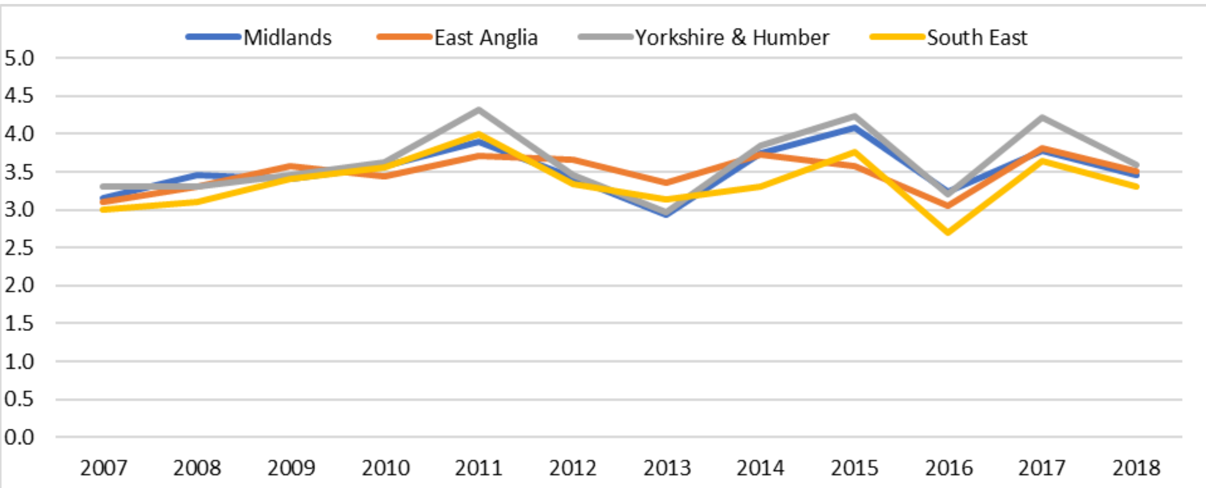
Figure 7 – Evolution of Rapeseed Area in the UK (ha)



Source: FAOStat

The production hotspots in the UK are located in Yorkshire, the East and West Midlands, East Anglia and the South East, which covers most of the arable regions of England. It is also important to consider, however, that rapeseed is grown in all other arable areas of the UK, including the east coast of Scotland.

Figure 8 – Evolution of Yields in Key Production Regions in the UK (t/ha)



Source: DEFRA

Average country yield in the UK is 3.5 t/ha, but it is possible for yields in hotspot regions to exceed 4 t/ha.

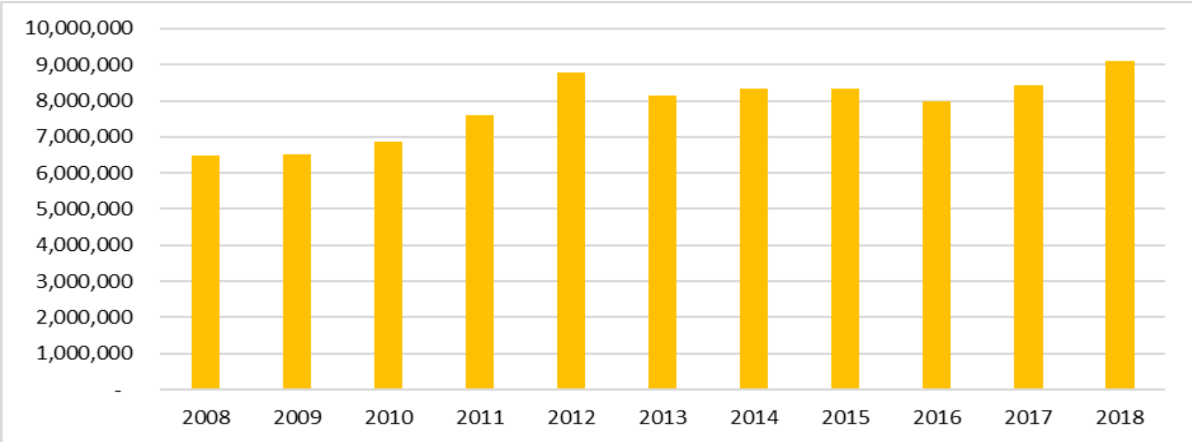
Yield developments have stagnated somewhat in recent years and are now indeed in decline in some areas due to the impact of rising pest prevalence and limited chemical treatments.

The majority of farmers implement either a direct seeding or minimum tillage system for rapeseed cultivation, although ploughing is still practiced by some farmers.

2.5 Canada

Canada is the world's largest producer and exporter of rapeseed (more commonly known as 'canola' in North America) and saw a dramatic rise in the planted area in the early 2000s coinciding with the introduction of new varieties. Rapeseed is now a major cash crop for many farmers in the prairie provinces of Canada, with an acreage of just over 8 million hectares.

Figure 9 – Evolution of Rapeseed Area in Canada (ha)



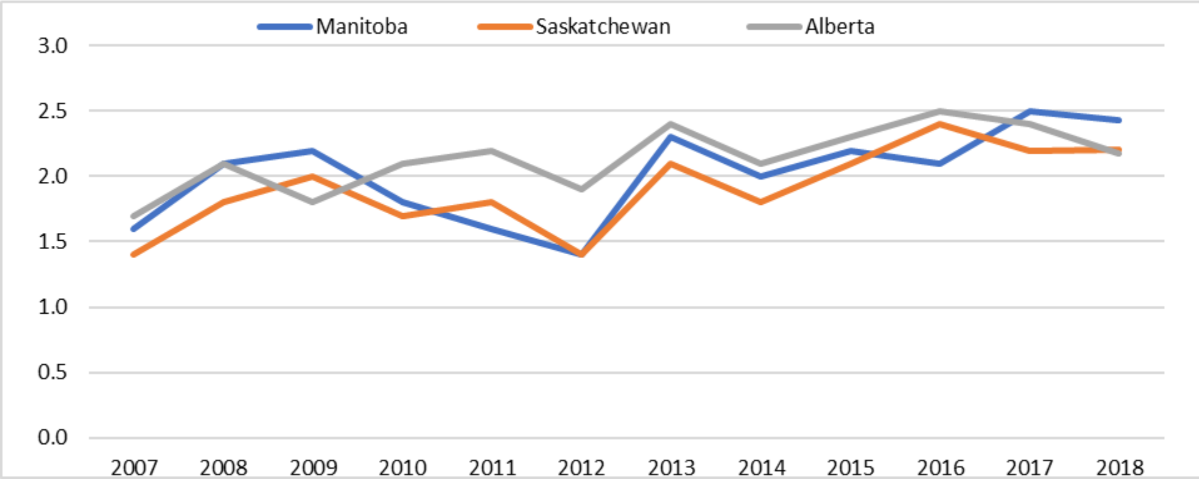
Source: FAOStat

Rapeseed is grown as a spring crop in rotation with spring cereals and legumes in the prairie provinces of Canada, typically being planted on approximately 33% of the farm. Some farmers may choose to grow rapeseed on the same land every second year, thereby accounting for up to 50% of their cropped area. Due to the very harsh winter climate (and the pervasiveness of pests) such a strategy is less risky than it sounds to those outside Canada.

With the tough climate and the shorter growing season of the Canadian Prairies, yields are significantly lower than in Europe, with a countrywide average yield of 2.5 t/ha in 2017. Due principally to difficult growing conditions, there is a great deal of yield variability, with an average range of 1.5 – 3.9 t/ha depending on the year and the region.

There has, however, been significant improvements in the average yield over the past 10 years for Canadian rapeseed, with further yield increases being expected as a result of variety development and the potential implementation of higher fertilization programmes.

Figure 10 – Evolution of Yields in Key Production Regions in Canada (t/ha)



Source: StatCan

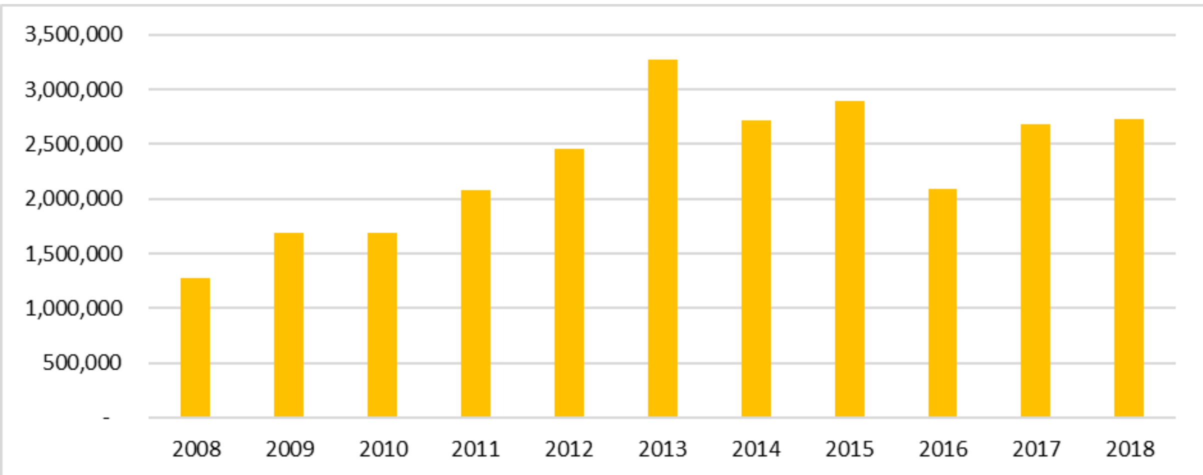
The majority of farmers operate a zero-tillage system for growing rapeseed. Many of the varieties used in Canada are genetically modified herbicide resistant, and there are a wider range of chemical treatments available to fight pests and diseases compared to Europe, where policy measures have reduced the treatment options considerably.

2.6 Australia

Australia is also a large-scale producer and exporter of rapeseed, although considerably behind Canada in terms of acreage and overall production figures. Rapeseed is grown as a winter crop in South Australia, New South Wales and Victoria, but the main hotspot region, where over 50% of the rapeseed is grown, is in Western Australia.

The crop is grown in rotation with wheat, barley or lupins, with pasture land (for sheep) occasionally being incorporated. Australian farmers do not tend to follow a strict pre-meditated crop rotation pattern, as commonly seen in Europe, due to the necessity for very specific growing conditions during planting in order to ensure the establishment and viability of the crop throughout the cultivation period. If conditions are not adequate, the land will either be left fallow or used as grazing land by sheep, before being returned to land for cereals production the following year.

Figure 11 – Evolution of Rapeseed Area in Australia (ha)



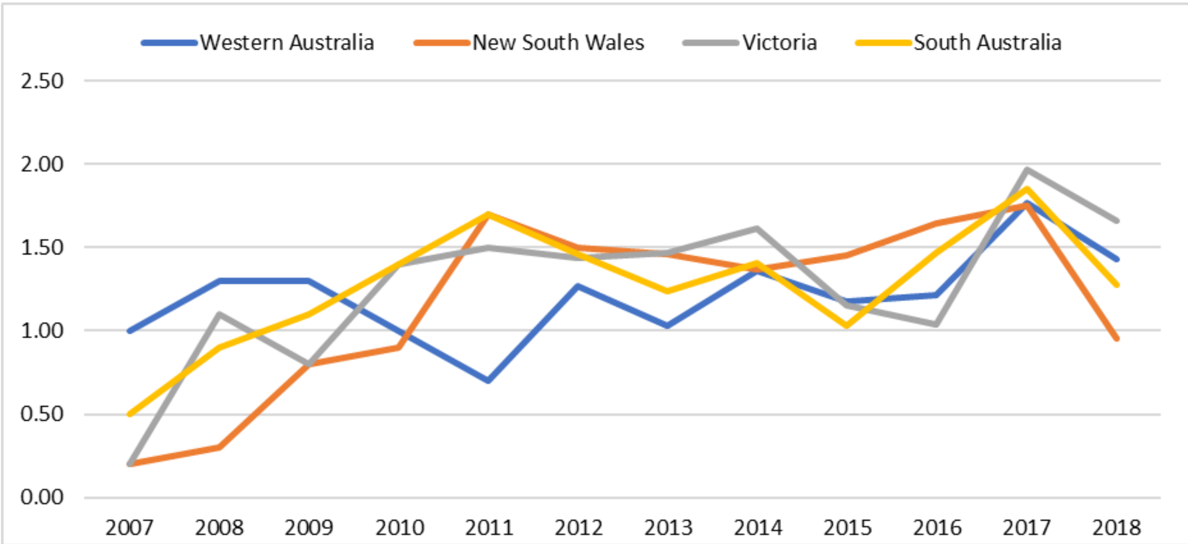
Source: ABARES

Production areas are split into rainfall zones in Western Australia, with designated High, Medium and Low rainfall zones.

Thus, yield levels differ considerably across the region. Furthermore, there is a great deal of variability from year to year, as the timing and amount of rainfall can vary significantly.

That said, there is a general trend of improving yields over the past 10 years. The average country yield is approximately 1.3 t/ha, where the average in the low rainfall zones is 0.9 t/ha, 1.5 t/ha in the medium rainfall zone and 2 t/ha in the high rainfall zone. As previously mentioned, these figures can vary substantially due primarily to environmental conditions; for example, it would not be unheard of to have a range of less than 0.5 t/ha in particularly poor years in the low rainfall zone to a potential high of 3 t/ha in high rainfall areas in particularly good years.

Figure 12 – Evolution of Yields in Key Production Regions in Australia (t/ha)



Source: ABARES

As with Canada, production systems are almost entirely zero tillage-based for rapeseed. Most of the rapeseed produced in Australia is also from herbicide resistant varieties, including both GM and non-GM techniques, but weed and insect resistance to chemical pesticide treatments is now becoming a significant issue for farmers. Inconsistent rainfall, however, remains the most significant threat to rapeseed production nationally.

3. CHALLENGES FACING RAPESEED PODUCTION IN SELECTED COUNTRIES

As part of the study, the consulted experts - mainly partners of *agri benchmark* from top rapeseed producing regions of the selected countries - were asked to complete a questionnaire detailing the major challenges facing producers in their respective countries. These evaluations were made based on regulatory, climate, pest and disease pressures, or market aspects; please see Appendix 1 for the list of questions.

Additionally, the experts were asked to outline their perceptions of the on-farm share of rapeseed in the rotation and how this has changed over the past 5 years; they were further asked what they believe the share of rapeseed will be in the next 5 years, based on the current situation, and why.

Finally, the experts were asked for their opinions on how fertiliser usage and crop care costs may change in the next 5 years, along with what impact this and other factors would have on yields over that time. A summary of the responses is given in Figure 13 below; full responses are available in Appendix 3.

In all countries, there is an expectation that crop care costs will increase by between 10 – 20%. In Europe, this is mainly attributed to increased pest constraints and the reduced availability of active ingredients to treat these pests and diseases. Canada and Australia, where the chemical options available are not as severely restricted, are facing increasing issues related to pesticide resistance; this is particularly true for herbicide resistant weeds in Australia.

Figure 13 - Summary of Anticipated Changes in Crop Establishment Costs

↑ ↓ **Increase/decrease 10% - 20%** ↑ ↓ **Increase/decrease 0% - 10%** → **Stays the same**

Country	Hot Spot Region	Anticipated Tillage system	Fertilizer Usage	Crop Care Costs	Change in Yields
Germany	N. Germany	Conservation tillage Some more ploughing	↓	↑	↑
	W. Germany		↓	→	→
Poland	W. Poland	Ploughing mulch and strip till	↓	↑	↑
UK	E. Anglia, Midlands, S. Yorkshire	Minimum tillage but some more ploughing too	↓	↑	→
France	N. W, E, Central and S-W France	Deep Tillage	↓	↑	→
Australia	W. Australia HRZ	Minimum tillage but some strategic tillage	↑	↑	→
	W. Australia MRZ	Minimum tillage	→	↑	→
	W. Australia LRZ	Minimum tillage	↓	↑	→
Canada	Prairie states	Minimum tillage	↑	↑	↑

Source: Arthey, compiled from expert questionnaire (2019)

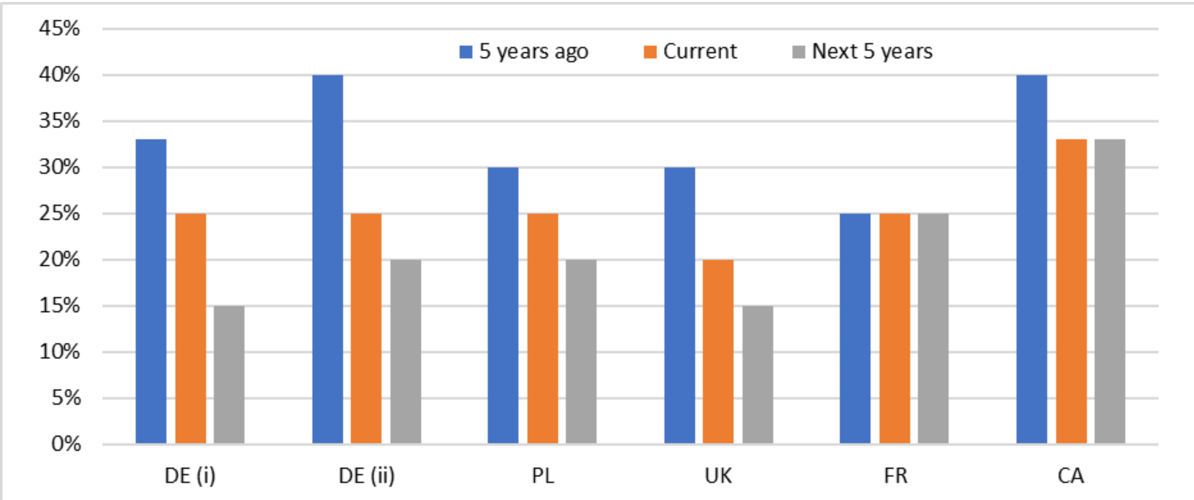
In Western Australia, the region is split according to climate and rainfall
HRZ = High Rainfall Zone (> 450mm); MRZ = Medium Rainfall Zone (325 – 450mm); Low Rainfall Zone (< 325 mm)

3.1 Crop Rotations

In terms of the share of rapeseed in the production system, many of the consulted experts from the European countries were of the opinion that the amount of rapeseed that producers choose to grow, and the frequency in which it is grown within the rotation, will likely decrease in the future.

The very tight rotations of growing rapeseed on the same land once every three years, or even once every two years are likely to be replaced by a wider rotation system with just 15 – 20% of a farm's cropped area being planted with rapeseed (or grown on the same land once every five or six years). The exception was the views of the French experts who were of the opinion that the share of rapeseed would not differ significantly from current levels. This is, however, potentially due to a generally lower share of cultivated area than is utilized in the other European countries, with many French farmers having a tendency to implement a more diverse crop rotation historically. This view is somewhat supported by the proportionately lower pest and disease concerns that the French country experts reported, compared to those of Germany, Poland and the UK. Furthermore, except for 2019, French rapeseed acreage has thus far been rather stable over recent years (see Figure 3), which is not the case for the UK and Germany.

Figure 14 – Expert Opinion on Change in Share of Rapeseed in the Rotation (%)



Source: Arthey, compiled from expert questionnaire (2019)

There are multiple factors behind farmers' decision to reduce the share of rapeseed in their rotation. Reducing the burden of disease, and particularly insect pressures, was cited by experts in all European countries. A wider rotation may reduce the extent of the pressure, while somewhat easing the cost burden of fighting against them with the limited chemical options available.

A further factor cited related to widening rotations, especially in the UK and northern Germany, is that it enables farmers to better implement measures to fight grass weeds in cereals. The early seeding dates for winter rapeseed do not allow time for weeds to flush and then be supressed. The result is that the following cereal crop has a higher weed burden. By widening the rotation and bringing in spring cropping as an alternative, weed suppression strategies can be better implemented, whilst also spreading the working time for labour and machinery.

In Canada, there has been a tendency over the last 5 years towards wider rotations rather than growing rapeseed on the same land every second year. This transition is possibly the result of growth in the pulses market, but the expectation is that farmers are unlikely to reduce the frequency of growing rapeseed any further within the next 5 years.

In Australia, rapeseed is likely to continue to be grown according to opportunity and depending on growing conditions, as well as the respective prices and economic performance of alternative enterprises, e.g., growing pulses or pasture for sheep. Pre-meditated rotation is therefore not implemented as a matter of course.

3.2 Nitrogen Fertiliser Input

Across all European countries, the experts anticipated that application rates for nitrogen fertiliser would reduce in rapeseed production in the next 5 years by 10 – 20%.

There are likely several reasons for this, but a major driver is the European nitrate directives surrounding water quality. Germany, in particular, is under pressure to reduce nitrate quantities in ground water; one of the proposed tools to do this is to restrict autumn fertiliser applications, especially in winter rapeseed. Furthermore, rapeseed is seen as a poor performing crop for Nitrogen Use Efficiency, leaving an N surplus for the following cereal, which, whilst beneficial to that following cereal, does also lead to an increased risk of leaching.

In the UK and France, the experts did not believe that reduced N applications would lead to a yield decrease because other management factors, such as greater adoption and use of precision fertiliser application technology, along with the continuing development of improved varieties for N Use Efficiency would offset the yield loss attributed to reduced fertiliser application.

In Poland, whilst there is the expectation of a reduction in N fertiliser application by up to 20%, a yield increase is actually anticipated as a result of improvements being made in management practices. Poland currently lags behind Western Europe in terms of yield performance; this is partly believed to be due to the slightly lower levels of technology adoption in comparison to Poland's Western European neighbours.

In Germany, there was an expectation of a 20% reduction in N application, but adoption of precision techniques and varieties with improved Nitrogen Use Efficiency would likely improve efficiency and limit yield loss.

In Canada, the situation is very different. The experts were of the opinion that Canadian producers currently under-apply N fertiliser; in combination with improved varieties, the application of 10 – 20% more N fertiliser would likely improve yields by 10 – 20%. Canada therefore has a distinct benefit for producers to embrace a higher input strategy.

In Western Australia, the expert believed that N fertiliser application strategies would increasingly differ depending on the rainfall zone. In the high rainfall zone, the expectation is that there will be a slight increase in fertiliser in an effort to gain higher yields. In mid rainfall zones, there was not expected to be any change to N applications or yield. In the low rainfall zone, the expectation was that there would be a 10% reduction in N fertiliser, but with an emphasis on greater adoption of precision technology to ensure fertiliser is available for the plant rather than broadcast.

3.3 Pest and Disease Challenges, and Crop Care Implications

In Europe, rapeseed is now facing some quite serious agronomic issues, especially concerning pests and diseases, which in some cases are making rapeseed exceedingly challenging to grow on a regular basis. One of the clear findings from the questionnaire and IRC workshop was the extent of the pest issues being faced, especially in Europe, and the limited chemical options available to fight them.

During the workshop, the country experts were joined by Mr. Andreas von Tiedemann, Head of the Division of Plant Pathology and Crop Protection, Department of Crop Sciences, Georg-August-University Göttingen, Germany. This section includes insight and data provided by Mr. von Tiedemann, in addition to the data from the country experts. Various data sources are therefore used within this section.

In northern Germany and the UK, cabbage stem flea beetle, in particular, is now a major concern that is threatening the overall viability of growing rapeseed in some areas, with planted area reducing throughout both countries.

Regarding the considered European countries, all of the agronomic experts cited the 2015 ban on neonic pesticides within the EU as being a key factor behind these increased pest difficulties. Alternative chemical options to neonics include pyrethroids, but these do not provide the same level of effectiveness against cabbage stem flea beetle, seed weevil, gall midge, pollen beetle and aphids; issues of insecticide resistance are therefore becoming more predominant.

Whilst insect pest issues the disease issues are two independent groups of biotic stresses, some pests may also be vectors for disease issues. This is, for example, the case with Aphids, who are virus vectors for Turnip Yellow Virus (TuYV).

Table 1 - Top 10 Pests and Diseases by Country/Region based on a global survey on experts' views

Red = Increased since 1995; **Green** = Decreased since 1995; **Black** = unchanged; n = number of expert reports

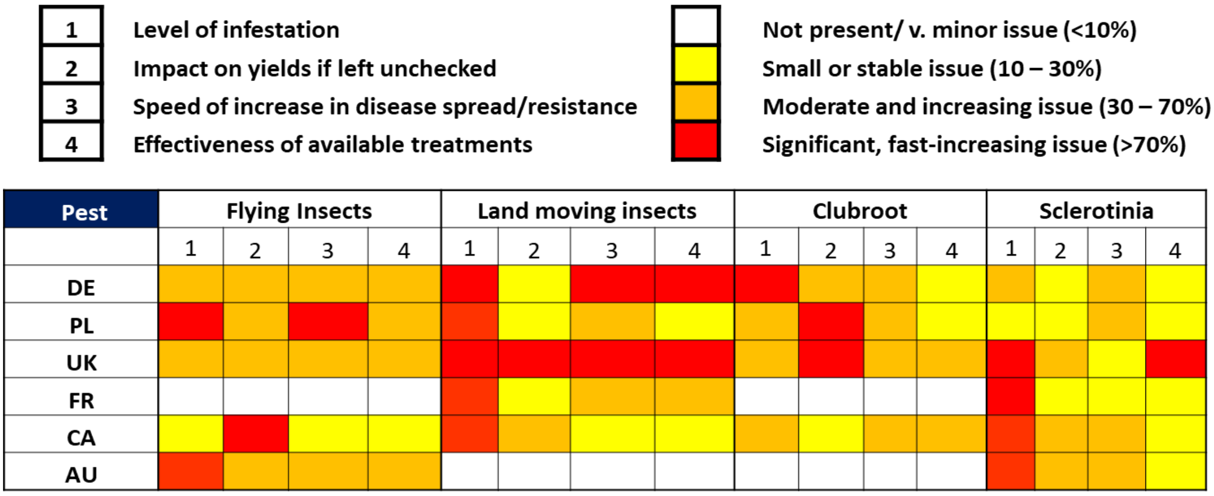
Australia (n=3)	**Europe** (n=8)	**China** (n=4)	**Canada** (n=1)
Insect pests	**Insect pests**	**Insect pests**	**Insect pests**
Red Legged Earth Mites	Flea beetles	Aphids	Flea beetles
Diseases	Pollen beetle	Flea beetles	Diamondback moth
Phoma stem canker	Rape stem weevil	Diamondback moth	Bertha armyworm
Sclerotinia stem rot	Brassica pod midge	Rape stem weevil	Cabbage seedpod weevil
White leaf spot	Aphids	Brassica leaf beetle	Lygus bugs
Downy mildew	**Diseases**	**Diseases**	**Diseases**
Viruses (TuYV/TuMV)	Sclerotinia stem rot	Sclerotinia stem rot	Clubroot
Powdery mildew	Phoma stem canker	Downy mildew	Sclerotinia stem rot
Clubroot	Verticillium stem striping	Viruses (TuYV/TuMV)	Phoma stem canker
Alternaria spots	Light leaf spot	Clubroot	*Aster yellows* phytoplasma
White rust	Clubroot	Alternaria spots	Seedling disease complex *)

Source: Pests & Disease ppt., A. von Tiedemann

* (Rhizoctonia, Fusarium, Pythium spp.)

The matrix in Figure 15 below shows how the *agri benchmark* experts from each country currently view various pest issues, as well as the degree of the issues. A detailed breakdown of the severity of particular pest issues is given in Appendix 4.

Figure 15. Pest and Disease Issues in Rapeseed-producing Countries (% impact)



Source: Arthey, compiled from expert questionnaire (2019)

Read me: to provide guidance on understanding Figure 15, the column numbers pertain to four key questions on the characteristics of the pest problem, and the colour coding relates to the severity of the issue. Red indicates a significant, widespread or fast increasing issue, orange a moderate but increasing issue, yellow a small, stable or localised issue, and white indicates a very small or minor issue that the partners did not feel posed a significant threat for farmers. The percentage ranges in brackets give quantitative context to questions 1 and 2, so for example, a red cell for question 1 - level of infestation - means that over 70% of the farms within the region are affected. Similarly, for question 2 – impact on yields if left unchecked – a red square indicates that over 70% of the yield would be lost if not treated. Question 3 – speed of increase in problem – is qualitative and relates directly to the descriptions in the key. Question 4 – effectiveness of available treatments – is also quantitative, where white would suggest near-total control by the available treatments (less than 10% loss), whilst red would indicate very little effectiveness (i.e. over 70% loss in yield regardless of treatment).

Neonics had their major efficacy in controlling sucking aphids and early pests, such as cabbage stem flea beetle, and cabbage fly. These mobile insects have been moving and infesting new areas in a relatively short time in recent years, and the country partners agreed that, in their view, this was due, in large part, to the neonics ban.

The continued high share of rapeseed in rotations have also provided a consistent and locally available host and source of food year-after-year with which they can multiply and spread quickly, and it is also the case that this has aided the fast increase in insect populations within and across regions, especially once the more effective chemical treatments have been removed.

*Table 2 - Top 10 Pests and Diseases in Europe: Survival & Range of Dissemination (*Without host)*

KEY: (+) = applies; + = strongly applies; +! = prevalent, powerful

Pest/disease	Survival* (years)	Range of dissemination	
		Field-bound	Landscape
Insect pests			
Cabbage stem flea beetle	<1		+!
Pollen beetle	<1		+!
Rape stem weevil	<1	(+)	+
Brassica pod midge	<1	(+)	+
Aphids	<1		+!
Fungal pathogens			
Sclerotinia stem rot	>4	+	
Phoma stem canker	<2	+ crop debris	(+)
Verticillium stem striping	<3	+	
Light leaf spot	<2	+ crop debris	(+)
Clubroot	<4	+	

Source: Pests & Disease ppt., A. von Tiedemann

Tight rotations have also been highlighted as a key reason for the spread of disease. This is particularly the case with Clubroot, which many experts believe has benefited from favourable climatic conditions, e.g., warm, wet soils at seeding time which exacerbate its incubation and spread.

Table 3 - Top 10 Pests and Diseases in Europe: Efficiency of Control

Pest/disease	Chemical	Biological	Efficiency of direct control
Insect pests			
Flea beetles	+	-	Compromised by loss of seed treatment + insecticide resistance
Pollen beetle	+	-	Affected by insecticide resistance
Rape stem weevil	+	-	Sufficient*
Brassica pod midge	+	-	Sufficient*
Aphids	+	-	Affected by insecticide resistance
Fungal pathogens			
Sclerotinia stem rot	+	+	High
Phoma stem canker	+	-	High
Verticillium stem striping	-	-	None
Light leaf spot	+	-	High
Clubroot	-	-	None

Source: Challenges and perspectives in Rapeseed Production: Pests & Disease ppt., A. von Tiedemann

Unlike diseases such as Sclerotinia and Phoma Stem Canker, existing chemical fungicide treatments are not effective at treating Clubroot or Verticillium. Management strategies therefore require an integrated approach, combining variety resistances, later seeding, spreading lime, and widening rotations so that European rapeseed is not grown on the same land so frequently.

The development and use of clubroot-resistant varieties is also seen as being a key strategy, but their effectiveness and the ability to maintain yields at current levels is a concern. Moreover, consistent use of resistant varieties will select for new virulence races breaking cultivar resistance.

The contrast to the feedback from the Canadian and Australian experts was notable in this regard. Whilst it is clear that many of the same pests issues are present in Canada and Australia, the key difference is in the response to what armoury of tools are currently available to combat the issues that arise.

In Figure 16 below, the experts were asked to provide details about current and next-available management tools to combat the various pest issues.

Figure 16 - Current Management Strategies in Rapeseed

Strategy is subject to policy restrictions in the EU — Strategy requires change in production system

1 = primary option 2 = alternative option

Pest	Flying Insects		Land moving insects		Clubroot		Sclerotinia	
	1	2	1	2	1	2	1	2
DE	CH	NA	CH	WR	WR,VS	WR	CH	BC
PL	M,CH	GCR	CH	WR	VS	WR		
UK	CH	BC	CH	WR	VS	DS	CH	WR
FR			CH	BC	VS		CH	BC
CA	CH	CH	CH	CH	GD,VS	CH	CH	GD
AU	CH	CH, GCR					PHM	CH

BC	Biological Control
CH	Chemical Application
DS	Delay Seeding
GD	Genetic Development
GCR	Green Corridor Removal
M	Mechanical
NA	None Available
PHM	Post Harvest Management
VS	Variety Selection
WR	Wider Rotation

Source: Arthey, compiled from expert questionnaire (2019)

Read me: to provide guidance in understanding figure 16, the column numbers relate to the two most common management options that farmers currently take in treating the pest/disease issue. The abbreviations in each cell are a description of what those management options are, so for example, "CH" indicates that chemical treatment is the most common method of treatment. Where more than none abbreviation is in the cell, this indicates that two different management options are combined, so, for example, "WR,VS" indicates that the management option would be to change to wider rotation and select appropriate varieties. The blue and yellow colours are intended to highlight threats to the production system. In the case of blue highlighted cells, this indicates that the management option is under an existing threat because of policy and legislative review, whilst yellow indicates that the management option requires more fundamental change in the whole-farm production system, that would impact on more than just the rapeseed crop.

In Canada and Australia, the suite of chemical options available to producers is still sufficient to combat, or at least diminish, the impact of these infestations. Furthermore, genetic development of new varieties allows for a quicker reaction to issues without initiating a significant impact on the production system.

In Europe, the primary chemical options have been considerably reduced in recent years; those that remain are limited, subject to resistance concerns, and under threat of removal as well. The alternative options for European farmers in many instances now include the introduction of more radical practice measures that would impact the entire production system.

The implication for this in Europe is that less rapeseed would be grown each year, with alternative break crops such as spring beans most likely to be introduced in its place. For the farm system, this could potentially mean the acreage of rapeseed that a farmer chooses to allocate to rapeseed each year will reduce, with a less profitable alternative crop, such as spring beans, planted in its place. This would likely lead to reduced farm profits.

In all European countries, there is the potential to see an increase in integrated pest management systems (IPM), whereby a combination of chemical, biological and mechanical strategies will be implemented. This includes strategies such as occasional changes to tillage practices, widening rotations and the removal of crop residues or volunteer rapeseed as combined strategies to combat disease in rapeseed.

These aforementioned practices are seen as relatively effective ways to combat increasing disease problems, but are generally less effective for pest management. Research undertaken by the Canola Council of Canada under the Canola Agronomic Research Program (CARP), suggests that retaining non-cultivated green areas are beneficial because they can create a habitat for the predators of rapeseed pests, thereby potentially serving as an IPM solution.

The experts recognized that while Europe (EU28) appears to be at the forefront when it comes to regulatory pressure on traditional chemical management options, Canada and Australia are not immune to having these issues become a threat in the near future. Negative perceptions persist around neonics, thus posing a major concern to Canadian producers in particular, given the impact that the ban appears to have had in Europe in a relatively short amount of time.

3.4 Potential Solutions via Resistance Breeding

The workshop also included insights and contributions from Mr. Martin Frauen of Norddeutsche Pfanzenzucht (NPZ) who is involved in the world of plant breeding solutions intended to withstand pest and disease concerns. The below mentioned points are his commentary on the status of breeding for traits against certain pests and disease.

i) Fungal diseases

Phoma: many options of keeping and improving the actual resistance level even against new pathotypes

Clubroot: good options of improving resistance level via traditional breeding techniques, nevertheless huge and aggressive variation of new pathotypes

Verticillium stripe: hard work to improve the resistance level significantly, medium resistance level and selection of tolerance on the way, new breeding techniques (gene editing could speed up the development

Sclerotinia: very hard work via traditional resistance breeding, nevertheless basic research and new breeding techniques will help within 10 years' time

Light leaf spot: higher resistance level possible, but stability of the resistance critical due to new aggressive pathotypes

ii) Insects

Many insects (in many regions more than 10 species) must be taken into account. For each species an individual breeding selection strategy must be established. Field tests are difficult to handle, expensive and laborious, and artificial infections are difficult and laborious. Experts on breeding of insect resistances are rare.

First research projects on steps for breeding insect resistances have started in Cabbage stem flea beetle (CSFB), Rape stem weevil, Pollen beetle and Cabbage seed pod weevil

To develop resistances via traditional breeding techniques needs up to 20 years. Selection via "bio marker" could speed up the selection. New breeding techniques like gene editing, and/or GM could speed up the development, but are currently banned in the EU.

iii) Virus

The most important is Turnip Yellow Virus (TuYV) which is well known for to European rapeseed breeders for many years. A resistance gene has been identified since mid-1990s.

Due to the ban of neonic seed treatments young rapeseed plants can be colonized is infected by green peach aphids which transmit TuYV. Up to now the TuYV resistance gene is effective, but there may are coming new pathotypes, therefore selection of field tolerance is going on as well.

4. ANALYSIS OF ON-FARM COMPETITIVENESS OF RAPESEED

This section uses data within the *agri benchmark* typical farm data set to analyse the respective competitiveness of growing rapeseed on farms in key production regions of the selected countries.

4.1 Methodology

The *agri benchmark* dataset is derived from using internationally standardised methods to collect data on farming production systems. This is done through the creation of a model of a 'typical farm', which is representative of the prevailing production system used in the production of mainstream cash crops for that country.

A 'typical farm' is defined as:

- being a dataset which describes a farm;
- being in a specific region which represents a major share of national output for the particular farm product under investigation;
- operating the predominant production system (farm enterprise) for this farm product in the selected region;
- reflecting the predominant combination of enterprises, as well as land and capital resource use, associated with the production of this farm product; and
- reflecting the predominant type of labor organization associated with the production of this farm product.

'Typical farms' are not averages of survey data because averages do not provide consistent production system data sets. Instead, the data is derived from focus groups with growers and advisors, where each value in the data set is obtained by consensus or based on specific individual farms which are 'typified' by replacing an actual farm's individual particularities, with data representing predominant characteristics, technologies and practices. The 'typical farm' is thus essentially a virtual farm.

This methodology provides a point of reference or baseline datum for comparison purposes, whether cross-sectional (same time, different places) or longitudinal (same place, different times).

Moreover, very detailed input information is identified, clarified and quantified (where applicable) through a data compilation and validation process using the focus groups. Members of the focus groups are all highly familiar with the farming systems, as well as the relevant value chains and their technical, economic, social and institutional environments. Standardized selection criteria and questionnaires are used in accordance with *agri benchmark*'s Standard Operating Procedure.

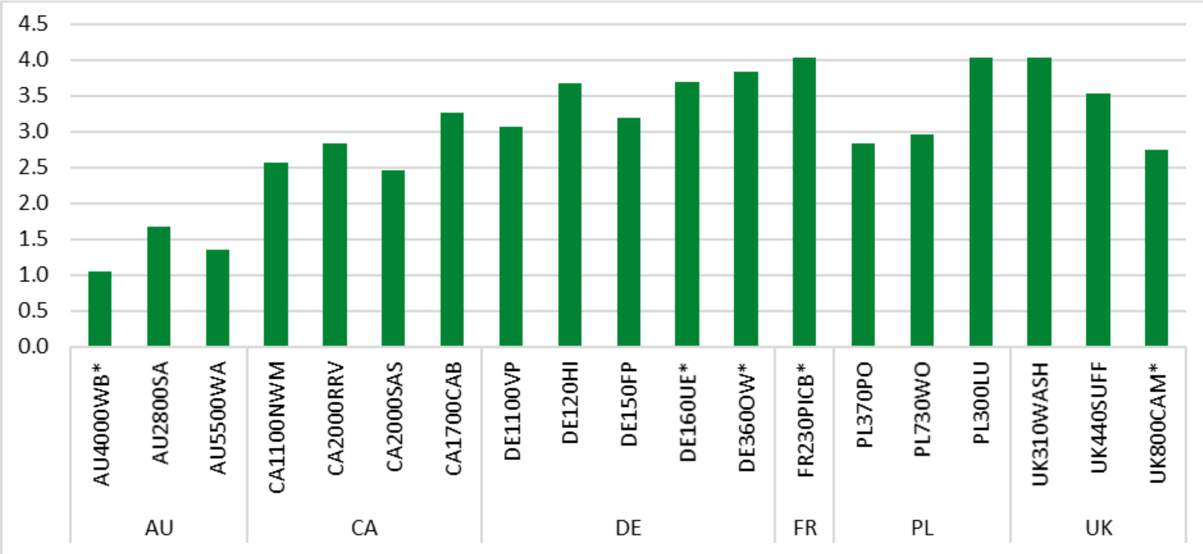
For the purposes of this report, typical farms were selected based on their production of rapeseed within each of the countries considered in this study; further, figures were based on the 3-year average between 2016 – 2018.

The typical farms are all within key rapeseed producing regions of each of the countries, details of which are provided in Appendix 2.

4.2 Yield

One major difference in the production systems between Australia, Canada and the evaluated European countries is the length of the growing season. In Europe, all the rapeseed crops in the dataset are grown as a winter crop over an 11-month time frame, whereas in Canada and Australia, the seasons are significantly shorter and face substantial constraints due to climate conditions.

Figure 17 – Rapeseed Yields on Typical Farms (2016-18 avg. t/ha)



Source: agri benchmark

In Australia, the crop is grown throughout the Australian winter over a 5-month period, but its success is very much dependent on the amount of moisture in the soil at the point of seeding, as well as levels of precipitation at key growth stages. It is therefore regarded as a serendipitous crop with comparatively little invested into it. The yields are therefore low and subject to a high degree of variability depending on the conditions of the year and the region.

In the Canadian Prairies, the growing season is very short due to the long and harsh winters, approximately 4 months from May to the beginning of September. Yield levels are lower than those achieved in Europe, although the gap has been closing over the past decade though improved varieties and technology advancement in Canada, while in Europe, no significant improvements have taken place in recent years.

In Europe, the yields achieved in Germany, France and the UK are relatively similar. Poland has slightly lower yields than its western European neighbours, which is attributed to various factors including colder winters, lower precipitation and varying soil quality.

4.3 Variable Costs

The investment in the establishment and care of rapeseed varies considerably amongst the different countries and production systems considered in this study. These differences are largely caused by differences in yield expectations, which are driven by different natural conditions; specifically, precipitation and the length of the growing season. Whether one system is ultimately deemed more costly than another can only be assessed when cost per tonne is considered.

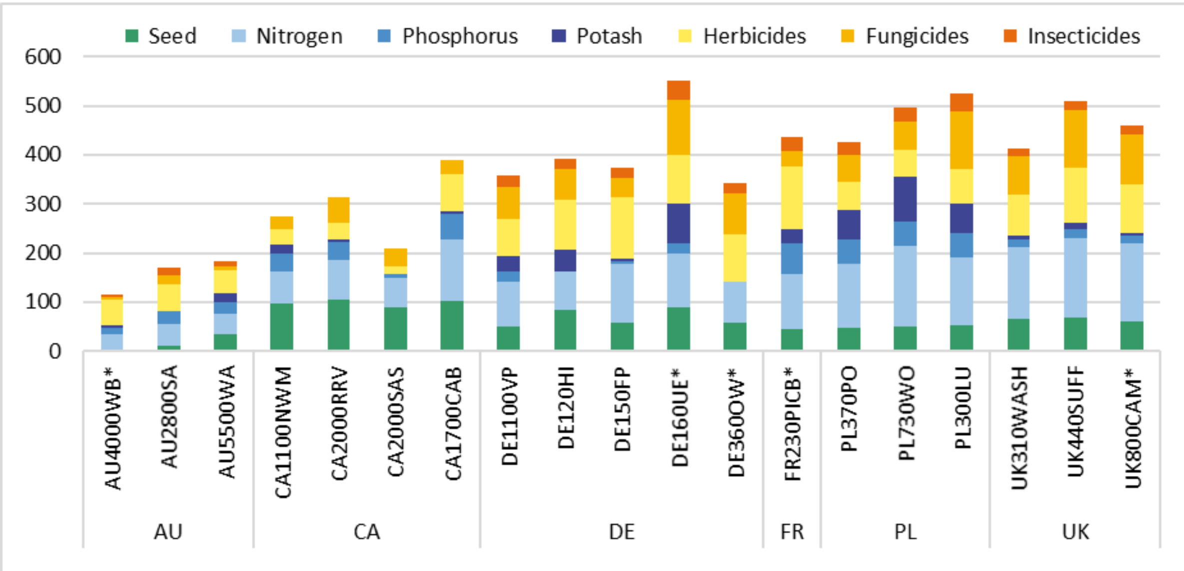
Australia and Canada, have substantially lower establishment and crop care costs when compared to Europe; albeit, some Canadian farms are moving towards European levels both in terms of input costs and achieved yields.

Australia has the lowest seed costs per hectare. This is due mainly to the low cost of rapeseed seed, rather than to lower seeding rates. The majority of seed is picked up as an End Point Royalty and deducted from the price of the sold tonnage rather than as a direct cost at seeding. The upfront cost of conventional varieties of farm saved seed is very low (€1 – 3 /kg), whereas the cost of Genetically Modified varieties is much higher (approximately €20/kg), as seen in AU5500WA, a typical farm in Australia. By contrast, the seeding rates for conventional varieties are higher at 3 – 4 kg/ha, while GM varieties are lower at approximately 1.5kg/ha.

In Canada, all farms use high seeding rates of 4 – 6 kg/ha and although the price of seed is at similar levels to prices seen in Europe, this accounts for the relatively high seed costs by comparison to the other countries.

In Europe, seeding rates range from 2 – 3.5 kg/ha, with somewhat higher costs for seed in Germany than in the other European countries.

Figure 18 – Variable Cost Breakdown in Rapeseed (€/ha; 2016 – 18 avg.)



Source: *agri benchmark*

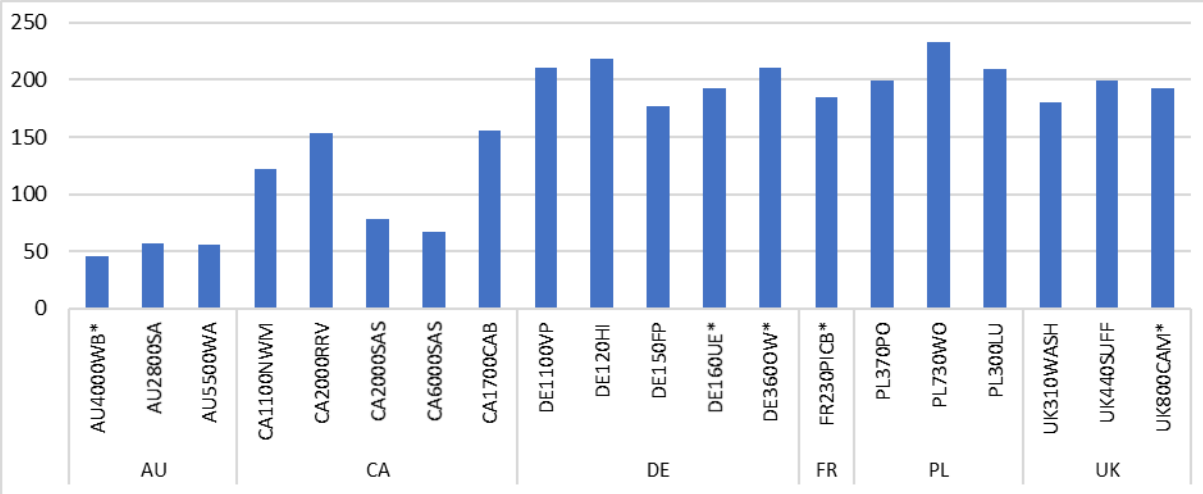
Fertiliser application costs are generally highest in Europe, with the UK and Poland spending similar amounts on Nitrogen, while costs are slightly lower than in France and Germany. There is greater variability on the Phosphorous and Potash costs within the European countries, due to the varying requirements of different soil types. The Polish typical farms have the highest overall fertiliser costs.

Fertiliser in Canada is split into two distinct groups: In Manitoba and Alberta, where growing conditions are slightly less challenging, the amount spent on fertiliser is similar to the figures on the typical farms in Germany. The typical farms in the harsher, low-precipitation conditions of Saskatchewan, however, require minimal fertiliser application, thereby on similar levels to those seen on the Australian typical farms.

In looking at Nitrogen application rates, the pattern is even more clear, with typical farms in Europe applying 175 – 240 kg of N, the higher yielding Canadian farms in Manitoba and Alberta applying 120

– 165 kg/ha, and the lower yielding farms in Canada and Australia typically applying less than 70 kg of N per ha.

Figure 19 – N-input in Rapeseed (kg/ha; 2016 – 18 avg.)



Source: agri benchmark

The biggest contrast between the Australia, Canadian and European typical farms is with regards to crop care costs.

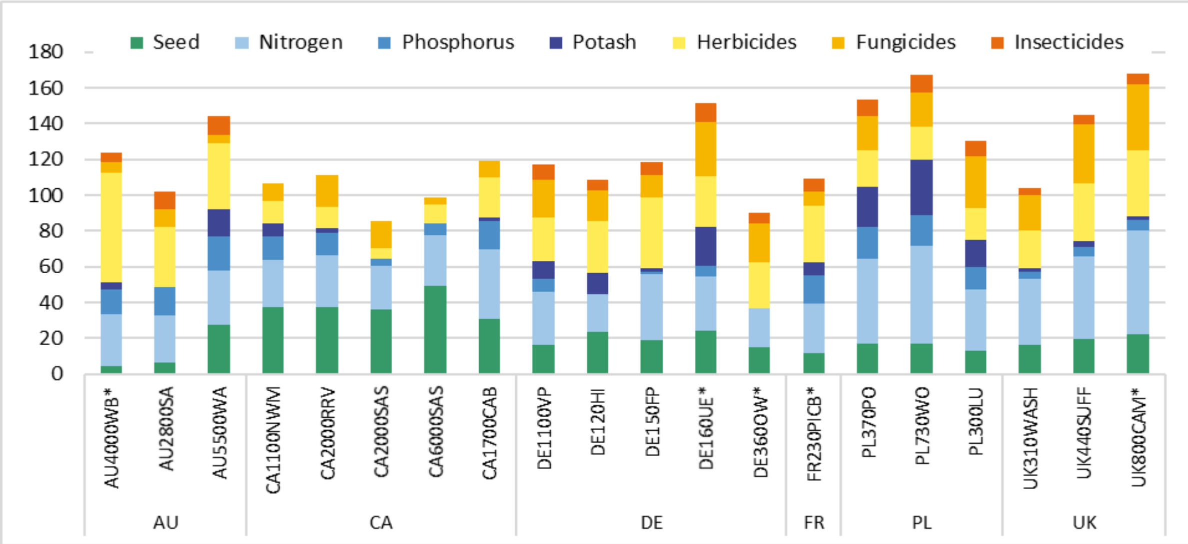
The cost of crop care in Australia, and in parts of Canada, is approximately 250% - 300% lower than in Europe. Pest issues do indeed exist in Australia and Canada, especially with regards to weed resistance in Australia, but there are also a number of tools to fight infestations, including a wider range of chemical treatment options. The dry conditions mean that there is a limited need for fungicide treatments. In Canada, the short growing season, cold winters and the availability of neonic treatments mean that the insecticide use on typical farms is very small, with infestations remaining at manageable levels.

In Europe, however, a number of typical farms spend over €200/ha on chemical treatments. Disease and insect treatment costs are significantly higher, both of which go hand in hand as insect damage opens the door to disease infection. Chemical treatment options have been substantially reduced since the neonicotinoids ban, while the active ingredients that remain are both expensive and, quite often, inefficient as resistance issues against pyrethroid products increase.

When looking at crop establishment on a per tonne basis (Figure 20), there is far less variability in the level of investment per tonne of output, with most farms spending between €100 – 130 per tonne. Typical farms in Poland and the UK generally have the highest crop establishment costs per tonne. This may, in part, be influenced by the exchange rate with the Euro, as it would for operating costs as well.

Differences between countries regarding the proportional make-up of establishment costs between seed, fertiliser and chemical costs, indicates that farmers around the world are in tune with the level of investment needed to competitively produce a tonne of rapeseed according to their specific growing conditions.

Figure 20 – Variable Cost Breakdown in Rapeseed (€/t; 2016 – 18 avg.)



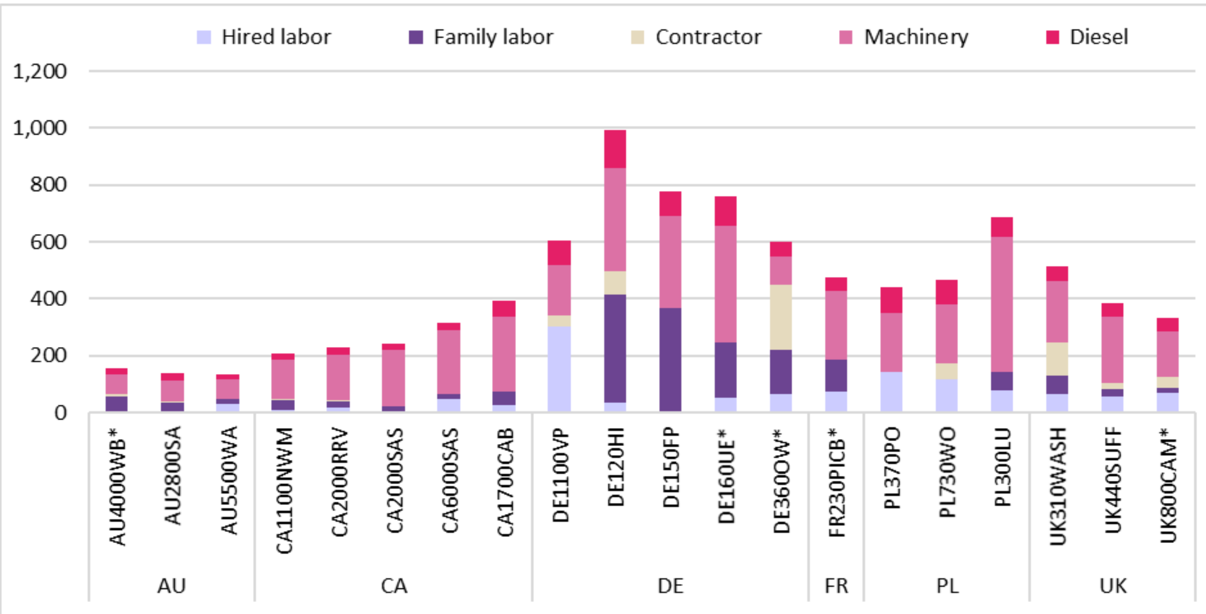
Source: agri benchmark

4.4 Operating costs

In terms of fixed costs, the competitive advantage that Australia and Canada enjoy over the European countries on a per hectare basis is principally down to scale of operation, as opposed to benefiting from cheaper labour and machinery costs; indeed, wage costs in Australia and Canada are substantially higher in some areas than in Europe.

The higher labour cost per hectare in Germany is mostly based primarily on their profile of being predominantly smaller family farms in which one or more family members receive their income from the farm. Typically, these farms also have a large machinery itinerary for their size, using more intensive cultivation techniques than those in Canada and Australia that are all direct-seeding based systems.

Figure 21 – Operating Cost Breakdown in Rapeseed (€/ha; 2016 – 18 avg.)



Source: agri benchmark

4.5 Total Cost and Revenue per Tonne

When looking at all cash and non-cash costs involved in the production of rapeseed on a per tonne basis, we see that there is a pattern of generally lower costs in Australia and Canada when compared to Europe. It should be kept in mind, however, that this data set for European farms from 2016 to 2018 is heavily influenced by the extreme drought conditions across Europe in 2018.

Opportunity costs are the total of calculated cost for the use of resources belonging to the grower and their family, which are not taken into consideration in the accounting books, such as equity, land and unpaid family labour. Calculations are made on the basis of what those resources could "earn" if not utilised on the farm, e.g., the rental equivalent for land, or the wage rate achievable by the family member given their experience and qualifications.

Cash costs include all cash outflows, including those for crop establishment costs, hired labour wage rates, land rents and interest.

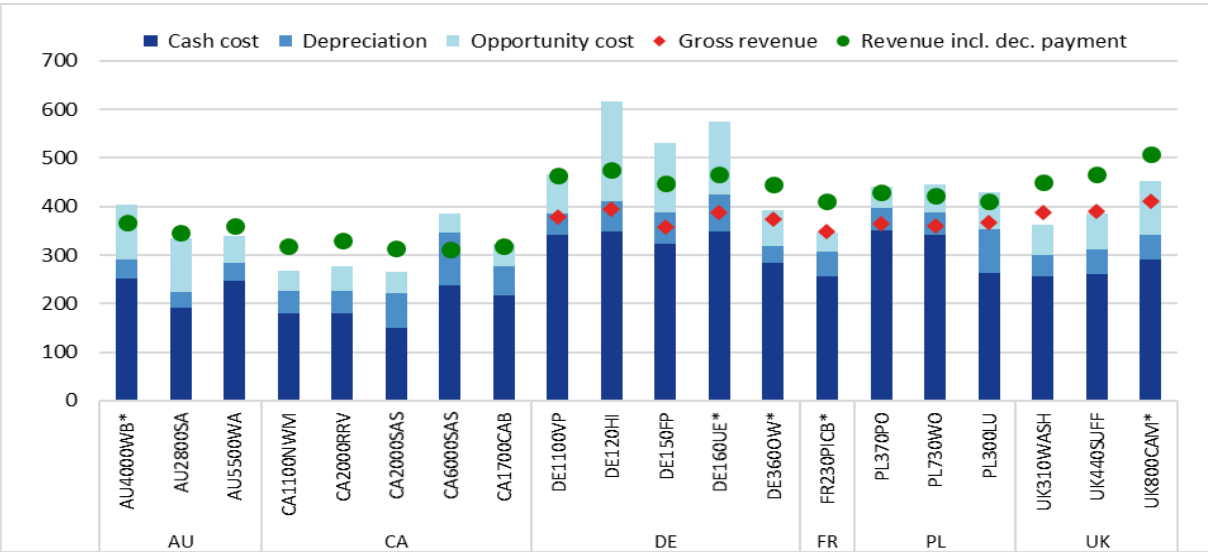
In terms of cash costs, the investment made in producing a tonne of rapeseed in Australia and Canada are generally lower than in their European counterparts.

Relatively high opportunity costs in Australia, however, limit the profit generated from growing rapeseed. In Canada, the typical farms in Manitoba and one in Saskatchewan are capable of making a clear profit by growing rapeseed, although this is not true for the lowest yielding Saskatchewan farm CA6000SAS nor for the highest yielding Canadian farm CA1700CAB in Alberta which have crop establishment costs similar to those in Europe.

In Europe, all typical farms also receive a decoupled subsidy payment for every hectare of land used in crop production, in addition to the revenue earned from rapeseed production.

Without this intervention, most of the German typical farms would barely be able to cover the cash costs; moreover, they wouldn't be capable of covering the non-cash depreciation and opportunity costs. Only the French and two of the UK typical farms are able to cover all costs without the subsidy payment. When the subsidy payments are included, the UK and French typical farms are capable of making a similar profit per tonne to the Canadian farms, which would otherwise be the most competitive of all typical farms.

Figure 22 – Total Costs of Production & Revenue (€/t; 2016 – 18 avg.)

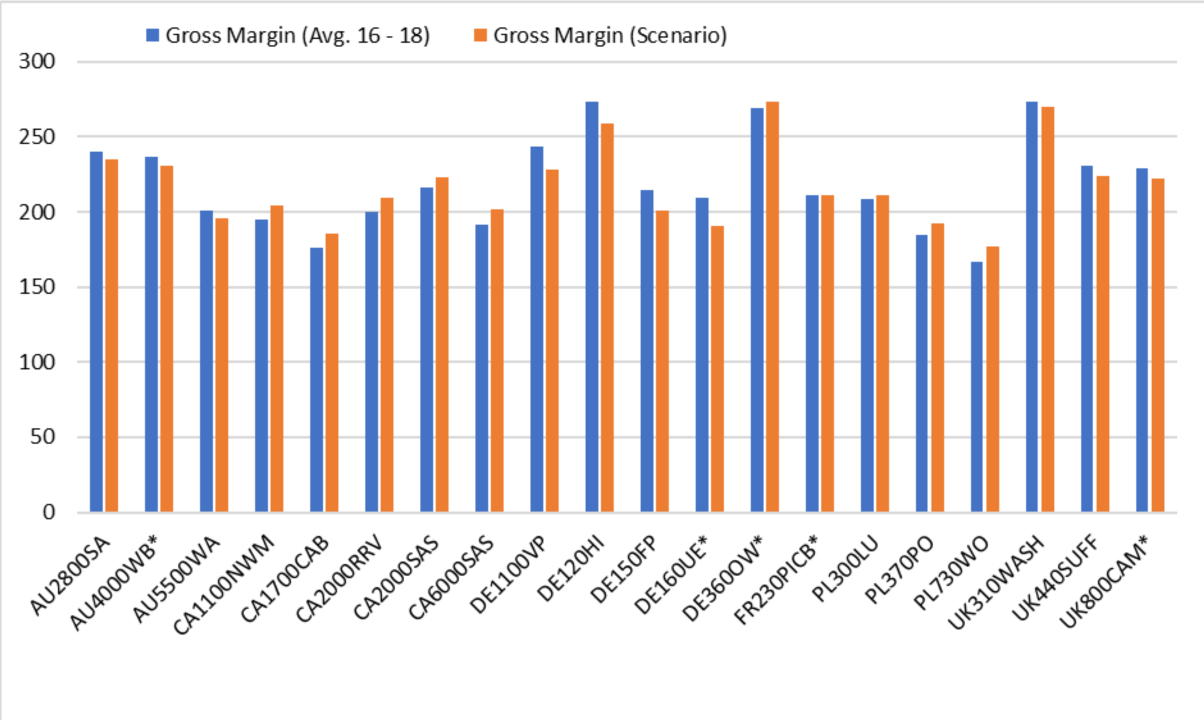


Source: agri benchmark

4.6 How will system changes affect gross margin performance?

Using the *agri benchmark* typical farm data, we have modelled the aforementioned changes summarised in Figure 13 of Section 3. The models help to project the impact of these changes on gross margins for rapeseed production across the considered countries. The calculations assume that crop prices, seed inputs and prices, and fertiliser prices all remain consistent with the 2016-18 averages. Only yield, N input and crop care costs have been adjusted.

Figure 23 – Change in Gross Margin as a Result of Changes (€/t)



Source: agri benchmark

On a per hectare basis, the scenario shows a modest improvement in the competitiveness of Canadian and Polish farms as yields increase. This gain is somewhat offset, however, by the increase in fertiliser applications and crop care costs.

Most of the German farms experience a decline in gross margin performance as a result of the increase in crop care costs, despite the reduction in fertiliser application. Yield levels are expected to remain at similar levels despite lower fertiliser application rates.

These changes in parameters would make the Canadian farms more competitive than many of the European farms.

Scenario calculations for the impact of wider rotations are discussed in Section 6 below.

4.7 Competitiveness of Rapeseed versus Alternative Crops

In addition to looking at the competitiveness of rapeseed grown in different regions of the world, in the context of this study, it is also important to consider how competitive rapeseed is against possible alternative crops in each of the evaluated countries.

A large part of the reason for the rapid expansion of rapeseed acreage since the 1980s is the relatively limited amount of alternative broadleaf crops. Broadleaf crops are needed to break the cycle of grassy crops such as wheat and barley, yet offer the same level of economic performance on a large scale. These crops have therefore become the favoured break-crop amongst cereal based rotations. Indeed, in some regions, they even out-perform cereal crops and have been seen as the cash cow within certain crop rotation programs.

However, with increasing crop establishment costs, and, in some cases, declining productivity due to increased pest and disease prevalence, the economic advantage that rapeseed had enjoyed over potential alternative break-crops, especially in Europe, has come under threat.

In this section, the economic performance of rapeseed is analysed against other competitor crops in the study countries and calculations are made for the threshold rapeseed yield that needs to be achieved in order to remain more competitive than the nearest alternative. By comparing the actual yield against the threshold yield, we will get a better understanding of the stability of rapeseed acreage for our typical farms, which, by definition, represent a major share of the respective rapeseed production in the considered countries. The larger the gap, the lower the probability that rapeseed acreage will come under pressure in the event that less effective crop care products are available to growers and overall growing conditions worsen, and vice versa.

As a matter of methodology, the 3-year average gross profit margin of rapeseed is taken against the 3-year gross profit margin performance of the most common alternative broadleaf crops that could be grown. This is before taking land costs into account because these costs would be the same for all alternative crops. We have then calculated how much the yield of rapeseed would have to reduce for the gross profit margin performance of the alternative crop to be competitive with rapeseed. The calculations assume that all other variable factors, such as input costs, fixed costs and crop prices, remain at the 3-year average. It should be noted that this definition parity in gross margins as the threshold for on-farm competitiveness is by no means a clear cut and uniform economic figure. Rather, it is only a rough indicator for the on-farm competitiveness. It is assumed that growers will start wondering about their rapeseed acreage – depending on the range of alternative crops with reasonable economic performance that can indeed replace rapeseed in a worst-case scenario once this benchmark is reached. In some cases, the need for a break-crop might be very high and profitable alternatives with much lower gross margins are expected by growers on a long-term basis.

In the case of Germany, the typical farms only include production data on potatoes and sugar beet as alternative broadleaf crops. Since these crops have very specific production systems, and could not replace rapeseed on a wider scale, it is therefore necessary to use local yield and input data from an alternative data source in order to measure against alternative protein crops (i.e., beans and pulses).

4.7.1 Results

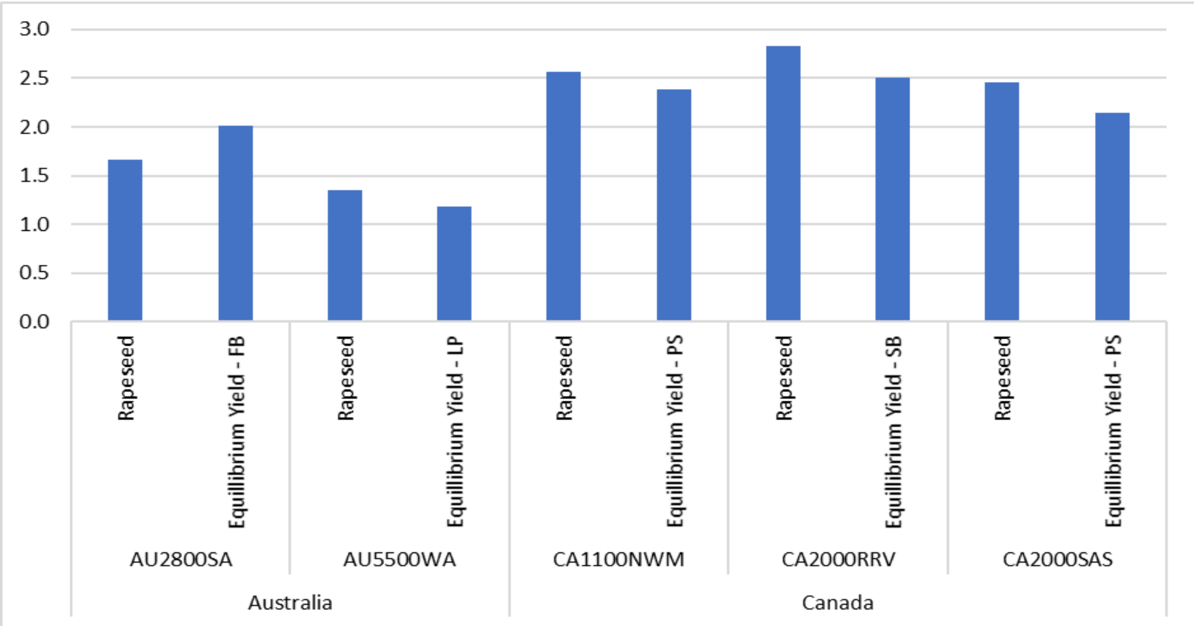
In Australia, alternative broadleaf crops to rapeseed include pulse and legume crops such as Fava Beans, Chickpeas and Lupins. Considering a 3-year average, *agri benchmark* typical farm data shows the gross profit margin performance of Fava Beans (FB) in AU2800SA to be better than rapeseed, with equilibrium yields suggesting that only when rapeseed reaches yields of 2 t/ha (20% increase from average) does it out compete Fava Beans. On typical farm AU5500WA, rapeseed levels would need to drop by 12% for Lupins (LP) to be a competitive alternative.

Despite the competitiveness of Fava Beans, and relatively small difference in gross margin performance to Lupins, it is not envisaged that these crops would take a significant share from rapeseed for two main reasons:

First, the global market demand for Fava Beans and Lupins is not large enough to sustain a major shift to these crops at scale. A sizeable increase in acreage would therefore likely lead to oversupply, reducing the price and, ultimately, the profit margin of the crop. Indeed, the price of these crops can be very volatile depending on demand from countries like India, which has a large impact on the world market.

Second, Australian farmers tend to grow pulses and legumes in combination with rapeseed as a risk mitigation strategy against unfavourable weather conditions. Pulses and legumes have greater drought tolerance than rapeseed, so farmers plant a proportion of their land with each crop so that they are not entirely reliant on the performance of just one. As previously stated, Australia is somewhat unique in that the decision of whether to grow rapeseed at all is driven by conditions at planting time. If conditions are not favourable at the time of seeding, they may alternatively opt to leave the land fallow or use it as pasture for sheep.

Figure 24 – Equilibrium Yield Rapeseed versus Competitor Crop, CA and AU (t/ha; 2016-18 avg.)



Source: *agri benchmark*

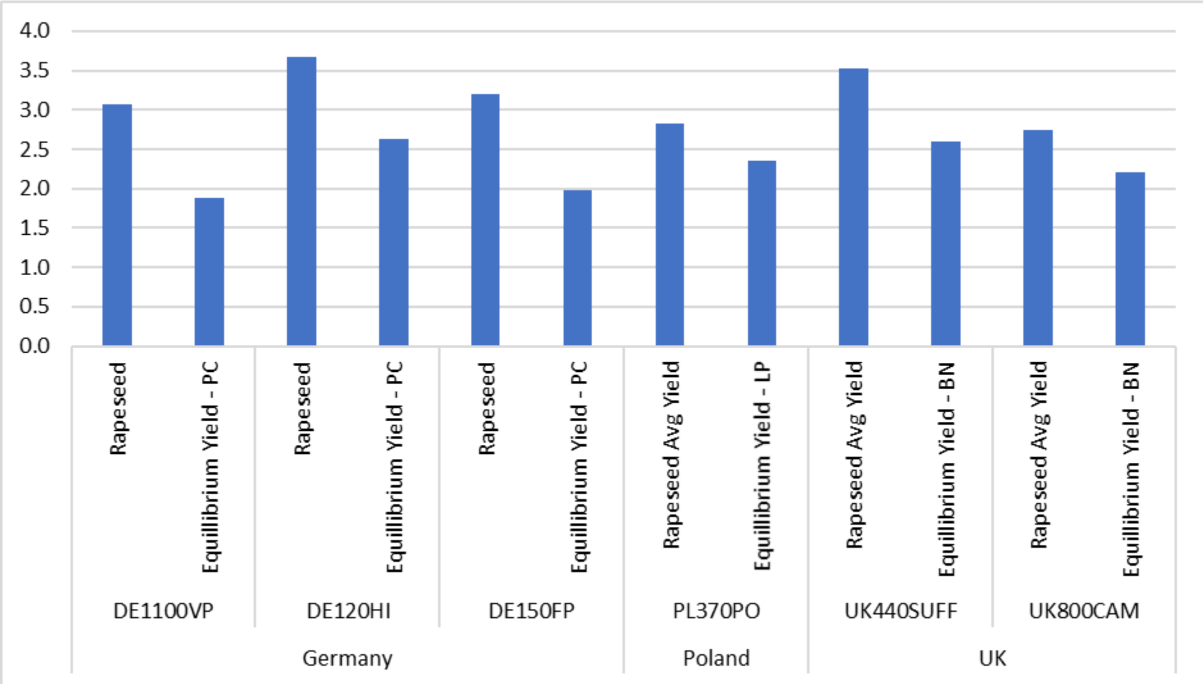
* FB = Fava Beans; LP = Lupins; PS = Peas; SB = Soybeans

In Canada, rapeseed is still the most widely grown and profitable cash crop for farmers in the prairie states, but pulses are a viable alternative., with only a relatively small drop in yields (less than 15%) determining the viability of pulses as an alternative. As with Australia, the size of the market for export is, however, a potential limiting factor to wide scale expansion.

As seen in CA2000RRV, soybeans (SB) increasingly serve as an alternative oilseed crop option to farmers. Variety and technology improvements have meant that this crop is increasingly being grown in the more western states. Further, other than in the case of pulses, the market for soybeans is almost “unlimited”. Hence, there will be no strategic restriction for growers to shift to soybean production in the event that rapeseed comes under pressure.

In Europe, despite there being greater challenges with rapeseed production (see Chapter 3 for details), the 3-year average yields would need to face decreases of >20% for alternative crops to be seen as better options due to the relatively limited options available for farmers.

Figure 25 – Equilibrium Yield Rapeseed versus Competitor Crop, Europe (t/ha; avg. 2016-18)



Source: agri benchmark, KTLB

* PC = Protein Crop (Beans, Peas and other Pulses); LP = Lupins; BN = Beans (Winter Field Beans)

In Germany, the alternative protein crops in the major rapeseed producing regions are still significantly less attractive than rapeseed. For those crops to be as economically viable, rapeseed yields would have to decrease by 35 - 40%.

This suggests that farmers will be reluctant to move away from rapeseed, even with a stagnating or even slightly declining yield performance due to the potential of their farms' economic performance to be significantly affected if they would switch to other crops. Additionally, it is necessary to keep in mind that some of the alternative crops such as beans and peas are very sensitive to shorter rotation cycles. At best, these options are therefore only a partial alternative crop to rapeseed, which often occupies up to a 33% share in rotations.

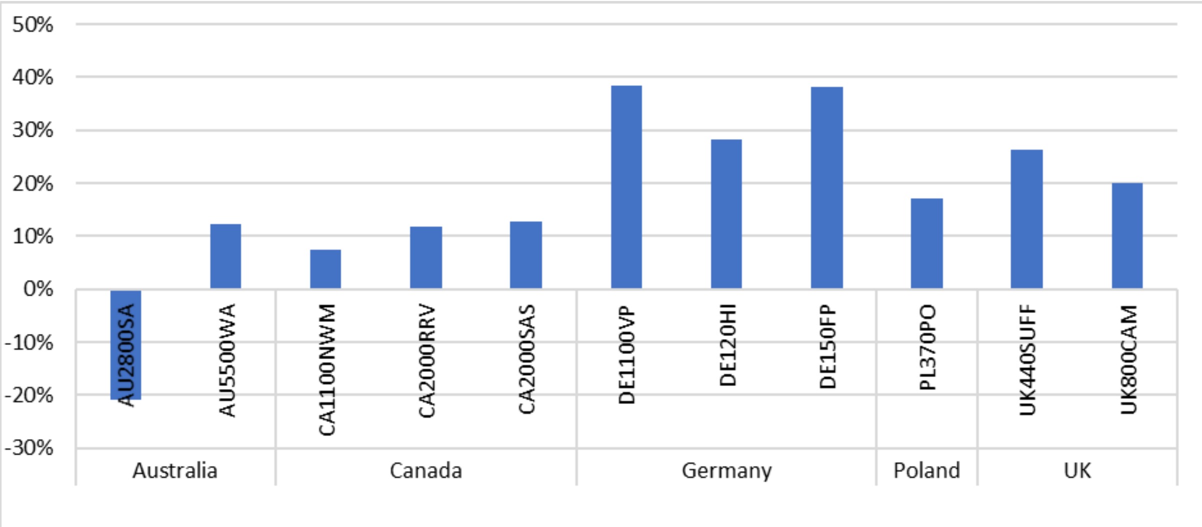
The *agri benchmark* typical farm data for PL370PO in Poland, where the land is of poor quality, suggests that the yield advantage rapeseed holds over other crops is not so significant. Here, the data compares lupins (LP) as a possible alternative to rapeseed, whereby yields would need to fall by 17% in order for a farmer to consider replacing their pre-existing share of rapeseed with more lupins. This is a possibility if pest issues increase even further, and if the market and price for lupins remained favourable.

The UK typical farms show a similar story of favourable performances of rapeseed over alternatives. Here winter beans (BN) are grown as an alternative broadleaf crop, with their gross profit margin performance being significantly lower than rapeseed. Figure 26 shows that rapeseed yields on the typical farms would need to decrease by approximately 20 - 25% for beans to be considered a viable alternative.

It should, however, be cautioned that the 3-year average from 2016-18 does not fully take into account the worsening financial performance of rapeseed on UK800CAM over that period. Following the neonics ban in 2015, performance on some farms has significantly declined. When taking 2018 as a standalone year, for example, the data for UK800CAM shows that beans actually break-even with rapeseed.

The large amount of rapeseed losses experienced both during autumn establishment and in spring due to pest problems in the UK, coupled with the additional attraction that beans allow for a greater window of time for supressing blackgrass before seeding can be viewed as a benefit to performance for the following wheat crop. It is quite possible that beans will begin taking a share from rapeseed cultivation in the future, especially in areas where pests are a problem.

Figure 26 – Reduction in Yield Required for Competitor Crop to be Competive



Source: agri benchmark, KTLB

5. ECONOMIC IMPACT OF SELECTED ALTERNATIVE MANAGEMENT SCENARIOS

In this section, we consider the economic impact of the main alternative management scenario options that farmers may choose when trying to lower the degree of pests and diseases on farms.

5.1 Wider Rotations

The major change that all country experts in Europe expect to see in the coming years is a move towards wider rotations, with the share of rapeseed decreasing from a 20 - 25% share of the cropped area down to 15 - 20% depending on the country (see Figure 14, Chapter 3). In Canada and Australia, no change from the current situation is expected.

In economic terms, rapeseed has traditionally been one of the best performing cash crops on European farms, often outperforming even wheat within the rotation. Even now, if a rapeseed crop can be successfully established, and avoid major pest and disease issues, it almost certainly performs favorably to other broadleaf break crops.

The consulted country experts believed that rotation shares would decrease due to the ever-increasing challenge in establishing and retaining an economically viable crop, along with the greater risk of crop failure. In the UK, for example, 10% of the national crop was written off between seeding in autumn 2018 and harvest in 2019 due to drought and cabbage stem flea beetle issues. The knock-on effect of this has been a reduction of an estimated 23% in planted area in autumn 2019 as farmers reduce their reliance on the crop.

The economic impact of this reduced dependence on rapeseed and the incorporation of wider rotation is significant where the alternative replacement crops in the rotation are limited and demonstrate poor economic performance by comparison.

Figure 27, below, demonstrates the impact on the total farm profitability of replacing some of the share of the rotation with alternative crops and widening the rotation (i.e., reducing the frequency in which rapeseed is grown on the same land).

Data has been used from typical farms in the UK and Poland, who have data on both rapeseed and on alternative replacement crops within their system. Keep in mind that these are simply scenarios and depending on the region, the profile of the farm and the market conditions, other alternative crops may be introduced instead that are more favorable.

It also needs to be stressed that the continuation of the current cropping system is, in most cases, only a hypothetical reference at this point in time. This further remains a hypothetical alternative as a result of the shortage of crop care products and the issues surrounding herbicide resistance, which cannot be realized until a grower accepts that this would generate much lower profits.

On the two UK typical farms, rapeseed has a 1/3rd share of the cropped area, whereas the scenario calculations limit the share to 1/5th of the cropped area in a 5-year rotation with wheat, winter beans and spring barley. Alternatively, a calculation was made relating to the impact of an even wider 7-year rotation with rapeseed having a 1/7th share of the cropped area; the result of this calculation fell in line with what the UK experts believe will be the direction of most UK producers in the next 5 years. The rotations sequence for both scenarios is shown below:

UK Farms:

5-year Rotation (Scenario 1)

Year 1	Year 2	Year 3	Year 4	Year 5
Rapeseed	W. Wheat	W. Beans	W. Wheat	S. Barley

7-year Rotation (Scenario 2)

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
W. Wheat	Rapeseed	W. Wheat	W. Bean	W. Wheat	S. Barley	W. Beans

The Polish typical farm, which is on relatively poor sandy soil and generally performs poorly, a comparison of the current rotation - which includes rapeseed having the highest share of cropped area with 1/3rd of the area - has been undertaken with a 4-year rotation scenario where rapeseed has a 1/4th share of the cropped area, as well as a 5-year rotation with rapeseed having a 1/5th share of the total cropped area. This is in line with the expectation of the Polish expert whereby farmers are expected to reduce their rapeseed area in the next 5 years. Here, the crop rotation includes winter barley, winter wheat and lupins, as well as rapeseed.

Poland Farm:

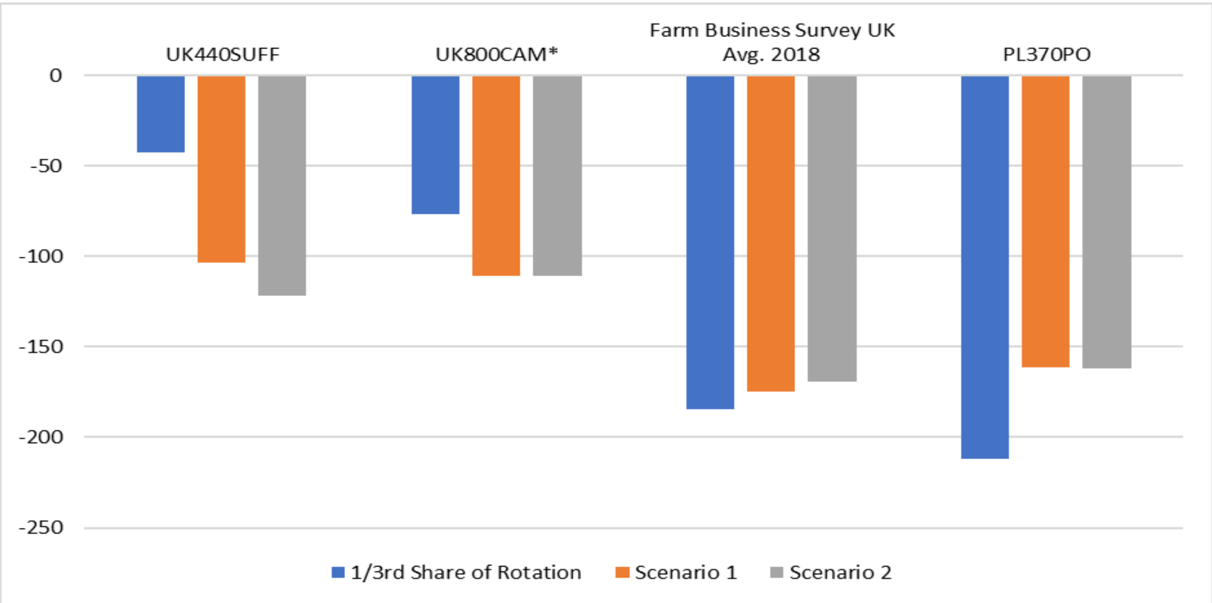
4-year Rotation (Scenario 1)

Year 1	Year 2	Year 3	Year 4
Rapeseed	W. Barley	Lupins	W. Wheat

5-year Rotation (Scenario 2)

Year 1	Year 2	Year 3	Year 4	Year 5
Rapeseed	W. Barley	Lupins	W. Wheat	W. Barley

Figure 27 – Whole Farm Avg. Profit/Loss under Current and Scenario rotations before subsidy (€/ha)



Source: *agri benchmark*, Farm Business Survey data

As seen in Figure 27, in regions and on farms where there is a low prevalence of pests (such as on UK440SUFF), the economic incentive to continue to grow rapeseed on a high share of available land (> 1/3rd of land) would be compelling, in principle, given that the alternative wider rotations are substantially worse in terms of economic performance.

Typical farm UK800CAM still currently cultivates a high share of rapeseed, yet the 3-year average yield has decreased from 3.74 t/ha (2013 – 15 average; thus, pre neonics ban) to 2.75 t/ha (2016 – 18 average; post neonics ban), suggesting that there have been increased levels of yield-damaging infestations during this time period, although drought conditions in 2018 somewhat exacerbated the decline.

By reducing rapeseed production to a 1/5th share in a 5-year rotation (Scenario 1), bringing in spring barley and increasing the share of beans in the cropped area, the performance of rapeseed would be likely to improve somewhat according to the 2016-18 average. In this scenario, a reduction in the pest burden was achieved through reduced host and food source availability. The experts believed that, in a 5-year rotation, this would improve rapeseed yields by approximately 20% from the 2016-18 average.

The overall economic performance, however, would still be reduced as a result of the other crops brought into the rotation being poor performing crops. Moreover, in reducing the rapeseed area, the share of wheat would also need to be reduced to accommodate the addition of another cereal in spring barley.

The same issues arise in a 7-year rotation (Scenario 2), as the wheat share is decreased to accommodate spring barley. However, as there is an even larger gap between rapeseed crops in the same field, the consulted experts believed that, in a 7-year rotation, this would improve rapeseed yields by approximately 30% from the 2016-18 average, which is still below the yield average achieved prior to the neonic ban. The data therefore suggests that there is not less of an economic benefit to growing rapeseed on a 7-year rotation as opposed to a 5-year rotation. The same pattern can be seen with respect to the scenarios considered for the Polish farms.

The UK's Farm Business Survey (FBS) data for 2018 (a year with widespread cabbage stem flea beetle and drought issues throughout England) is provided as an example of the economic performance of rapeseed in a poor growing year after the neonics ban. Here, the Farm Business Survey recorded an average total production cost of €453/ha for rapeseed on farms in England, resulting in a loss of €180/ha.

Situations where there are high incidence of pest issues, demonstrates that persevering with rapeseed at a high share is not an option for farmers. However, the benefit of a wider rotation, employed as part of an integrated management approach with the use of the remaining available chemicals means that it is possible that the pest pressures could be reduced. Scenario calculations for the FBS farm therefore account for a yield increase of 10% in rapeseed.

The typical farm PL370PO in Poland is on land of poor quality. The alternative broadleaf crop here is lupins and the introduction of a wider rotation is actually deemed to be a better option due to the anticipation of knock-on benefits for yield improvements in all other crops, including cereals. A greater crop share of lupins would also improve the margins due to their better economic performance on the farm. It should be cautioned, however, that a widespread increase in the amount of lupins grown, which already has a relatively small global market demand when compared to rapeseed and other commodity crops, could lead to oversupply; a reduction in farmgate prices and therefore margins would follow. It is also unlikely that lupins would outperform rapeseed on all soil types.

5.2 Alternative Pest Treatments for Rapeseed

As well as widening rotations, farmers may also need to implement alternative treatment options when it gets to a point that the existing chemical treatments are either no longer effective on their own, are restricted or have even been eliminated through policy changes.

Experts indicated that the destruction of the "green bridges" that allow the survival of pests and diseases should also be implemented. This includes removal of volunteer rapeseed that could act as a food source and harbor pests even in years when rapeseed was not otherwise grown, as well as crop residues from the previous harvest. In contrast, the encouragement of "green corridors" for the promotion of beneficial insects should be considered as a natural control strategy.

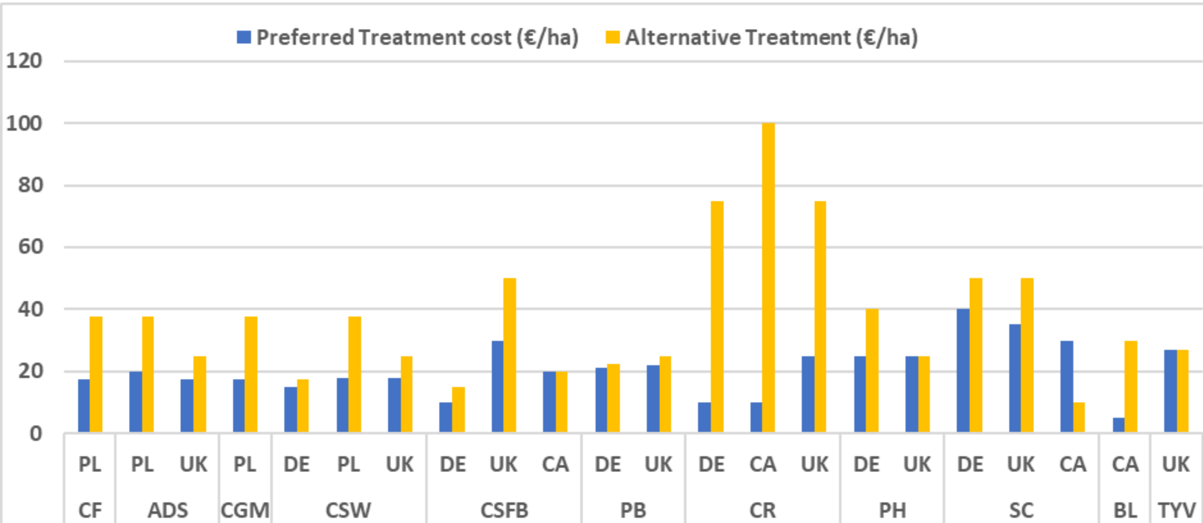
An alternative potential solution that is still in the early stages of development and adoption by producers, is the use of biological foliar sprays that encourage beneficial bacteria. These may be used either instead or in combination with chemical applications. Early results suggest that this approach only has a moderate level of effectiveness as a standalone management tool, but greater effectiveness may be reached in combination with chemical treatments.

A treatment in the early stages of adoption for Sclerotinia, for example, is through use of Coniothyrium minitans, a beneficial fungus that is sprayed on the soil during cultivation. This fungus attacks Sclerotinia in the soil and reduces its impact on the subsequent crop.

In the questionnaire, the country experts were asked to provide details of alternative treatments, including the indicative cost of the measure and the degree of yield this would help to maintain when compared to existing treatments.

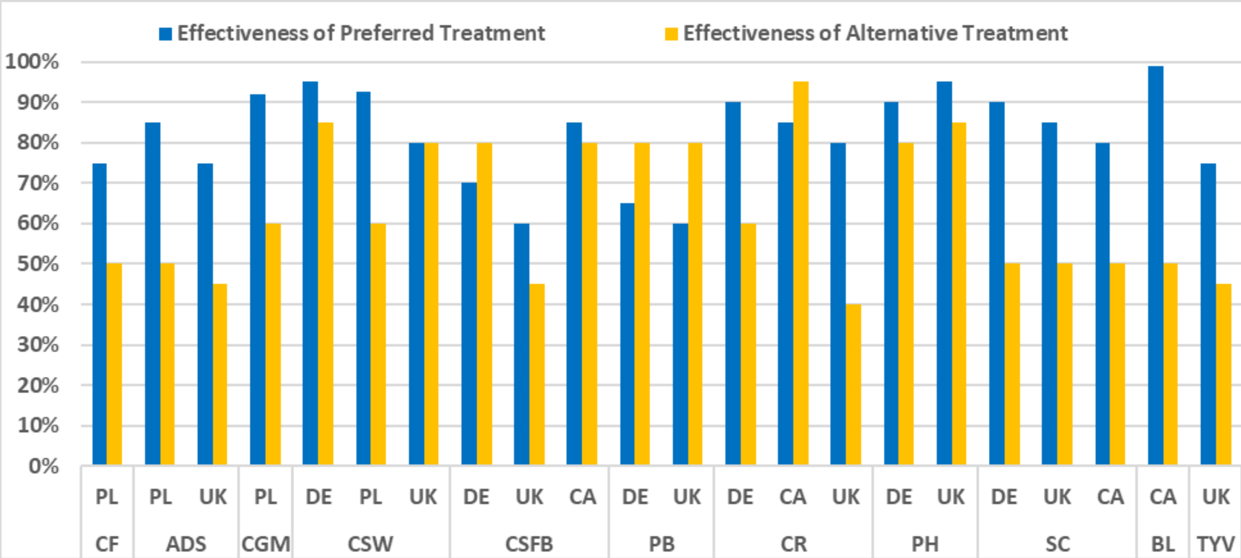
Figure 28 provides an estimate of treatment costs compared to the existing method. An indication of the effectiveness of the treatment in terms of the level of yield that could be maintained as a result of the treatment in areas where the pest or disease was prevalent is also shown in the graph.

Figure 28 – Cost of Preferred Pest/Disease Treatment versus Next Alternative (€/ha)



Source: Arthey, compiled from expert questionnaire

Figure 29 – Estimated Effectiveness of Treatment on Maintaining Yield (% of optimal yield)



Source: Arthey, compiled from expert questionnaire

Abbreviations Key

Pests	Diseases
ADS – Aphids	CR – Club Root
BA – Bertha Armyworm	SC – Sclerotinia stem rot
CF – Cabbage Fly	LLF – Light Leaf Spot
LB – Lygus Bugs	BL – Black Leg
PB – Pollen Beatle	SDC – Seedling Disease complex
RSW – Rape Stem Weevil	DO – Damping Off
SS – Slugs and Snails	TYV – Turnip Yellow Virus
CSW – Cabbage Seed Weevil	VS – Verticillium Stripe
CGM – Cabbage Gall Midge	PH – Phoma
DBM – Diamondback Moth	
CSFB – Cabbage Stem Flea Beetle	
RLEM – Redleg Earth Mite	

What is quite clear from the data is that the alternative treatments are, in most instances, more expensive and less effective. This would therefore have an impact on the margins that could be achieved for rapeseed in the future.

Some of the alternative treatments are part of an integrated management approach that includes widening the rotation. Treatment costs in these cases may not be substantially different from existing treatment, and yields may actually be improved, but this does not factor in the economic implication of a wider rotation on the total farm income. This may add a further implied “cost” being linked to the treatment in situations where the wider rotation leads to a decrease in overall farm income.

6. STEPS TO FIND SOLUTIONS TO PEST & DISEASE CHALLENGES

As part of the workshop held at the International Rapeseed Congress (IRC), the participants were asked to consider and debate what steps should be taken to find solutions to the pest and disease issues mentioned in Chapter 3. The expert panel included representatives from all study countries and covering expertise in farm economics, agronomy, plant breeding, entomology and pathology, as well as in commercial agronomic consultancy and rapeseed production. Therefore, the panel represented many of the different perspectives of the challenges in rapeseed production. A list of the participants and their professional background is given in Chapter 1.

The aim of part of the workshop was to develop a list of priority recommendations that could be taken into account in order to prevent, or at least limit, the impact of pests and disease in rapeseed in the future. Recommendations for policy makers and value chain actors in the input and services industries were also established.

The recommendations that were discussed included the following:

i) **Green Corridors** - more understanding is needed on the positive role that green corridors can play in hosting "beneficial" insects that are able to combat and reduce the populations of damaging pests. Margins around field edges may be able to provide a habitat for these beneficial insects. More work needs to be done in order to better understand what the positive insects are, how effective they are and what types of habitat conditions are conducive to hosting them. It was noted that the Canola Council of Canada is already administering research into this through the Canola Agronomic Research Program (CARP).

ii) **Zoning** – little is known about the migratory patterns of insects, especially related to how long they can survive and travel without rapeseed as a host and food source. This is particularly relevant for wingless insects, such as the Cabbage Stem Flea Beetle, which spreads quickly across regions now that neonic insecticides are banned. The workshop proposed that a study on zoning, that coordinates the complete restriction on growing rapeseed in a region for a number of years, should be undertaken to see how long it takes for an insect pressure to develop thereafter. The experts believed that a distance of 10 – 15 km to any rapeseed fields would be needed to avoid infestation.

Further investigation would require coordinated work with farmers and local policy makers to ensure long-term compliance with the study. If such a method was successful, coordinated and cooperative management of rotations would then be required.

iii) **Levy on cost of chemicals** – the experts were in agreement that a significant factor in the development of pest and disease issues is the historical overuse of chemical treatments. This has both caused harm to beneficial predatory insects that would ordinarily assist in keeping populations of negative insects in check, but regular use of the same class of pesticide treatment has also resulted in increased levels of resistance against certain products.

The experts suggested that a good solution to this problem would be to provide a levy on all chemical sprays, at €20 per ha. This would raise much needed funds which could later be reinvested in producer-level projects, such as trials for alternatives.

iv) **Assessment and Identification** – experts believed that steps should be taken to improve the pest identification and assessment process carried out in fields, i.e., adopting a field/crop scouting model, for more precise decision making related to the necessity and timing of chemical treatments. This would include an assessment of the level of infestation and economic risk to the crop, rather than a precautionary application against possible infestation or infection, which has both an economic impact and may ultimately increase the likelihood of resistance.

v) **Digital Identification** – a recommendation was made that more work needs to be done on understanding whether digital identification technologies for pest and disease might be instrumental in mitigating and managing related crop challenges.

vi) **Cultivar Varieties** – more research needs to be done on determining which cultivar varieties have the required vigor and are best equipped to withstand pests and disease. Furthermore, information should be provided to producers to indicate which cultivar varieties are best used in their area based on how prone to certain pests or disease issues these cultivars are.

7. CONCLUSIONS

Over the past 30 years, rapeseed has become one of the most important cash crops on farms across northern and western Europe, Australia and Canada, providing farmers with a high performing break-crop in cereal-dominated rotations. The success of rapeseed was based on strong yield growth on the basis of heavy investments in breeding, the ever-increasing use of crop care products and better crop management.

However, its success and popularity amongst broadacre farmers has now become a key reason why the viability of rapeseed is under serious threat in some regions, particularly in Europe, where pest and disease concerns have dramatically increased, especially following the elimination of key chemicals such as neonicotinoid pest control treatments in 2015.

The area of rapeseed has, in some European regions, been declining at an alarming rate since its peak in 2012/13. This investigation found that producers in hotspot regions in Germany, Poland and the UK were all faced with similar issues of increasing pest and disease prevalence in rapeseed, with rapid spread of both winged and windless insects following the neonic ban. Moreover, these increasingly present insects are opening the door to greater secondary disease infections.

In France, many of the same issues with wingless insects have been experienced, but the pest and disease pressures were generally deemed to be less significant than in neighbouring European countries. It is thought that due to the historically wider crop rotations in France, it has been harder for pests to establish populations in an area and spread across a region as quickly.

The limited chemical treatment options still available in the EU to combat pests are now beginning to face regulation and resistance issues. Furthermore, the next available measures often require more radical changes to the production system, to include an integrated management approach using chemical, biological and mechanical means, as well as wider rotations. These points clearly have economic implications for farmers and result in an expectation of lower farm incomes.

In the case of wider rotations, farmers in some regions may consider growing rapeseed on the same land once every 5 or even 7 years in order to limit the establishment of pests. The hypothetical analysis in this investigation reveals that the implication for whole farm financial performance from taking such measures could be losses of approximately € 100 – €175 /ha, but in areas where pest and other growing obstacles are already significant, the status quo of narrow rapeseed rotations is no longer an option, with similar or even greater whole farm losses now being experienced.

Finding ways to improve the economic viability of alternative break crops is therefore of key importance to producers. In certain regions, Lupins can offer a more profitable alternative, but the market is relatively small, and fairly volatile, so this does not offer a widespread solution for European producers. Field beans and peas have a need for considerable improvement in order to offer the same level of competitiveness, although the benefits to a following cereal crop and saving on nitrogen fertiliser should not be underestimated.

In Australia and Canada, it was clear from our workshop and study that, whilst European producers are at the forefront of these challenges, farmers in these countries are not immune. Resistance issues, especially with weeds in Australia, coupled with challenging climatic conditions and drought, mean that Australian rapeseed is seeing competition for acreage from legumes, as well as pasture for sheep.

In Canada, despite having the benefit of a much larger range of chemical products, and potentially genetically modified varieties, there are also resistance issues. This is especially true concerning pests such as the cabbage stem flea beetle, seed weevil and Diamondback Moth.

Following changes in regulation and permitted usage of neonic pesticide products in the EU, the Canadian Government also implemented its own review of neonics. Seed treatments on Canadian rapeseed were deemed satisfactory, yet political pressure remains from environmental groups to limit or eliminate neonic products. The regulatory situation should be closely monitored because the implication of a total neonics ban could be significantly damaging to rapeseed production in a very short period of time, given the amount of rapeseed grown and the tight rotations Canadian producers employ. The experience of European producers is a potential snapshot into the future in this regard.

The workshop on challenges and perspectives in global rapeseed production at the International Rapeseed Congress included the establishment of a number of steps and recommendations for further monitoring and evaluating that could help to guide policy and assist producers in overcoming problems that they currently face.

At a policy and scientific level, the panel of experts recommended that more research should be undertaken to understand the benefits that beneficial predator insects play in combating insect pests, along with the role that green corridors can play in providing a habitat for these beneficial insects. Work is already being done by the Canola Council of Canada in this regard under its CARP program.

Similarly, the panel recommended that a large-scale zoning study should be undertaken, whereby a suspension is initiated on rapeseed production for a period of years to understand whether resident pest populations can remain dormant in the landscape and/or how long it takes for pests to return once rapeseed is grown again. This would require substantial coordination and cooperation between policy makers, scientists and producers on a large-scale.

At a field-scale level, the panel recommended that coordinated work needs to be done to provide standardized methods for the assessment and identification of pest and disease. This recommendation is intended to be employed directly by producers. Moreover, the role of digital technology should also be considered in this regard.

It is further recommended that the use of pesticides also needs to be better managed in an effort to prevent resistance issues, perhaps by way of introducing a levy to limit over-application of the few chemical options left in Europe.

At a crop breeding level, it is suggested that further research into the vigour of different cultivar varieties against pests and disease should be undertaken to enable improved information availability on what varieties work best in given circumstances. In a long-term view, new breeding techniques (e.g. gene editing) and/or use of genetically modified adoption could speed up the development of resistant varieties.

All of these recommendations and study initiatives should be carried out under the umbrella of a joint global platform that should be further developed and maintained to enable stakeholders from the rapeseed value chain to better share their experiences of the challenges in rapeseed production, along with what can be done to combat these challenges.

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Appendix 1 – Questionnaire to Country Experts

Questionnaire Sheet 1 - Current situation and available treatments

Question 1	**Hot spot region for rapeseed production**
Question 2	**Name of pest**
Question 3	**Type of pest**
Question 4	**Level of risk of infestation in region (widespread, moderate, localised)** *widespread = affects >60% of regions' rapeseed area* *moderate = affects 40% - 60% of regions' rapeseed area* *localised = affects < 40% of regions' rapeseed area*
Question 5	**Potential rapeseed yield without pest infestation (t/ha)**
Question 6	**Typical reduction in yield if infestation is treated too late (% range)**
Question 7	**What are the main trends of this issue over the last 3 - 5 years?**
Question 8	**What is the expected trend of this pest issue in the next 5 years (pls. also take into account shortage of products)?**
Question 9	**Most common management strategy for treatment?**
Question 10	**Treatment type (chemical, biological, mechanical, integrated)**
Question 11	**Effectiveness of existing treatment if treated at optimal time (% of potential yield maintained)**
Question 12	**Approximate cost of treatment (range of €/ha)**
Question 13	**What alternative treatment do farmers implement to combat this pest issue, if any?**
Question 14	**Treatment type (chemical, biological, mechanical, integrated)**
Question 15	**Effectiveness of measure on rapeseed yield (% of potential yield maintained)**
Question 16	**Approximate cost of treatment (range of €/ha)**
Question 17	**What new products/treatments are being trialled to combat this pest, if known?**
Question 18	**Treatment type (chemical, biological, mechanical, integrated)**
Question 19	**Effectiveness of measure on rapeseed yield (% of potential yield maintained)**
Question 20	**Approximate cost of treatment (range of €/ha)**

Questionnaire Sheet 2 – Current and future management changes

<table>
<tr><td>Question 1</td><td colspan="3">Hot spot region for rapeseed production</td></tr>
<tr><td>Question 2</td><td colspan="3">Current typical yields of rapeseed in hotspot region (typical range in t/ha)</td></tr>
<tr><td>Question 3</td><td colspan="3">What is the current share of rapeseed in a typical rotation (% of cropped area on farm)</td></tr>
<tr><td>Question 4</td><td colspan="3">What was the share of rapeseed in the typical rotation 5 years ago (% of cropped area on farm)</td></tr>
<tr><td>Question 5</td><td colspan="3">What do you expect the share of rapeseed in the typical rotation will be in 5 years’ time (% of cropped area on farm)</td></tr>
<tr><td rowspan="2">Question 6</td><td colspan="3">What are the three major drivers behind any anticipated change in the share of rapeseed in the rotation? (rank the major drivers behind farmers rotation decisions according to importance (3 = most important)</td></tr>
<tr><td>1</td><td>2</td><td>3</td></tr>
<tr><td>Question 7</td><td colspan="3">What is the most common tillage type used in rapeseed establishment in the region?</td></tr>
<tr><td>Question 8</td><td colspan="3">What change, if any, would you expect there to be to the tillage type commonly used in rapeseed establishment in the next years?</td></tr>
<tr><td>Question 9</td><td colspan="3">What will be the main reason for changing tillage practices in rapeseed establishment in the next years?</td></tr>
<tr><td>Question 10</td><td colspan="3">What change to fertiliser usage do you expect management changes to have in rapeseed (% change from current)</td></tr>
<tr><td>Question 11</td><td colspan="3">What change to crop protection costs do you expect management changes to have in rapeseed (% change from current)</td></tr>
<tr><td>Question 12</td><td colspan="3">What impact, if any, do you expect management changes will have on yields of rapeseed (% change from current)</td></tr>
</table>

Questionnaire Sheet 3 – Further information on pests (where known)

Question 1	**Name of pest pressures**
Question 2	**Type of pest**
Question 3	**Ability to feed on other crops/crop residues over winter**
Question 4	**Ability to survive in the soil**
Question 5	**Ability to cope with intensive tillage**
Question 6	**Ability to develop with different crop density measures**
Question 7	**Any other parameters that may be influenced through agricultural practices**

Appendix 2 – Locations of Typical Farms

Country	Typical Farm	Region
Australia	AU4000WB*	Low Rainfall Zone, central Wheat Belt, Tammin Western Australia
	AU2800SA	Lower North, nr Adelaide, South Australia
	AU5500WA	Northern Region, Mullewa, Western Australia
Canada	CA1100NWM	North West Manitoba
	CA2000RRV	Red River Valley, Manitoba
	CA2000SAS	Saskatchewan
	CA1700CAB	Central Alberta
Germany	DE1100VP	Mecklenburg-Vorpommern
	DE120HI	Hildesheim, Niedersachsen
	DE150FP	Frankische Platte
	DE160UE*	Uelzen, Niedersachsen
	DE360OW*	Ostwestfalen, Nordrhein-Westfalen
France	FR230PICB*	Picardy, North West France
Poland	PL370PO	Pomeranian Voivodeship
	PL370OW	Wagrowiec Greater Poland Voivodeship
	PL300LU	Zamosc, Lubelskie Voivodeship
UK	UK310WASH	Lincolnshire Wash, England
	UK440SUFF	Suffolk, England
	UK800CAM*	Cambridgeshire, England

* denotes a leading-edge farm (a top producer for the country/region)

Appendix 3 – Full Responses on Changes to Production System

Country/Region	Main issues currently affecting rapeseed production	Impact on share of rapeseed in the rotation	Likely change in fertiliser and crop care over next 5 years	Current vs anticipated impact on yield
Western Australia High Rainfall Zone	- Upper canopy blackleg issues - Price/margin of rapeseed vs alternative crops - Sheep as a better alternative	Not applicable given the opportune nature of rapeseed production	- Increase in N application likely - 15% increase in crop care costs	- Yields maintained/ slightly improved with hybrids. At around 2 t/ha avg.
Western Australia Mid Rainfall Zone	- Lack of moisture at seeding - Price/margin of rapeseed vs alternative crops - Pulses as a better alternative	Not applicable given the opportune nature of rapeseed production	- No change in N application - 10% increase in crop care costs	- Yields maintained at around 1.5 t/ha avg.
Western Australia Low Rainfall Zone	- Reduced growing season from climate change - Lack of water at seeding		- 10% reduction in N application through precision application - 10 % increase in crop care costs	- Yields maintained at around 0.9 t/ha avg.
Canada Prairie States	- Spread of clubroot across the country - Increasing issues with trade and regulations	Unlikely to have a serious impact on share of rapeseed in the rotation	- Increase in fertiliser usage to increase yields - Crop protection costs expected to increase	- Avg. 2.3 t/ha expected to increase to > 3.3 t/ha avg.
N-Western Germany	- Restrictions on fertiliser application - Reduced crop care products - Yield volatility due to insects and climate	Reduce by circa 5%	- 20% reduction in fertiliser usage - No change to crop care costs	- Yields remain stagnant at approx 3.8 t/ha avg.
N-Eastern Germany	- Grass weed pressure affects following cereals - High insect burden in rapeseed - Reduced crop care chemical products	Reduce by 5 – 10%	- 10 – 20% reduction in N fertiliser application - 10 – 20% increase in crop care costs	- Reduce circa 5% from 3.75 t/ha to 3.56 t/h avg.
W and Central Poland	- Precipitation and timing - Insect pressure in rapeseed - Reduced crop care chemical products	Reduce by circa 5%	- Reduce by up to 20% in N fertiliser application - Up 20% in crop care	- Yields have potential to improve 5 – 10% from 3.25 t/ha to 3.5 t/ha avg.
N France	- Build-up of pest pressures - Lack of crop care products	Reduce by circa 5%	- Likely reduction in N-application	
W France	- Build-up of pest pressures - Lack of crop care products	Reduce by circa 5%	- Likely reduction in N-application	
E & Central France	- Build-up of pest pressures - Lack of crop care products	Reduce by circa 5%	- Likely reduction in N-application	
S-W France	- Build-up of pest pressures - Lack of crop care products	Reduce by circa 5%	- Likely reduction in N-application	
E Midlands, E Anglia, S Yorkshire, UK	- Control blackgrass in cereals - Increasing pest pressures - Reduced crop care products	Reduce by circa 5 - 10%	- Reduce N fertiliser input by 10% - Crop care costs increase 10 – 20%	- Yields remain stagnant at approximately 3.8 t/ha avg.

Appendix 4 – Pest and Disease Concerns by Country

Pests		Diseases
AS – Aphids	CSW – Cabbage Seed Weevil	LLF – Light Leaf Spot
BA – Bertha Armyworm	CGM – Cabbage Gall Midge	CR – Clubroot
CF – Cabbage Fly	DBM – Diamondback Moth	SC – Sclerotinia stem rot
LB – Lygus Bugs	CSFB – Cabbage Stem Flea Beetle	BL – Black Leg
PB – Pollen Beatle	RLEM – Redleg Earth Mite	SDC – Seedling Disease complex
RSW – Rape Stem Weevil	SS – Slugs and Snails	DO – Damping Off
		TYV – Turnip Yellow Virus
		VS – Verticillium Stripe
		PH - Phoma

Key

1	Level of infestation	Not identified as an important issue (<10%)
2	Impact on yields if left unchecked	Small or stable issue (10 – 30%)
3	Speed of increase in disease spread/resistance	Moderate and increasing issue (30 – 70%)
4	Effectiveness of available treatments	Significant, fast-increasing issue (>70%)

Europe

Pest	CF				AS				CGM				CSW				CSFB				PB				RSW				SS			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
DE																																
PL																																
UK																																
FR (i)																									*	*	*	*				
FR (ii)																																

Disease	CR				VS				LLF				SC				PH				TYV			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
DE																								
PL																								
UK																								
FR (i)																								
FR (ii)																								

FR (i) is North, Western, Eastern and Central France) FR (ii) is South-West France; * only applies to East and Central France

Canada and Australia

Pests	BA				DBM				LB				CSW				CSFB				ADS – TYV				RLEM				SS			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
CA																																
AU																																

Disease	CR				VS				BL				SC				SDC				DO			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
CA																								
AU																								