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Restricted availability of azole-based fungicides: impacts on EU farmers and crop agriculture

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Executive Summary

Introduction

The focus of this study is on the role played in crop protection by a particular group of active substances, the triazoles or, more simply, azoles. The azoles are a group of chemical compounds which are used to protect cereals and other crops from devastating key fungal diseases. Septoria and rust are the two main diseases that adversely impact the productivity of cereals. Azoles are critical to controlling septoria and rust and maintaining cereal productivity. Only a few classes of fungicides have shown to be as robust over many years of use as the azoles. Among the azoles, especially the value of epoxiconazole to the grower is emphasized by its frequent use in the major cereal growing countries in the EU.

Regulatory developments in the EU could lead to the prohibition of some azoles, with potentially serious consequences for European agriculture. The objective of this socio-economic study is to simulate different scenarios in case of a prohibition/limitation of azoles, in order to assess the degree of damage and negative effects quantitatively and qualitatively for European agriculture. The purpose of the study is to create a better understanding among relevant stakeholders with regard to the importance of azoles for farmers and the food industry.

Methodologies used

This study assesses the implications of a restriction on the availability of azoles for crop protection both at farm level and for European agriculture generally. Farm-level effects are demonstrated by estimating the impact on gross margins and farm net income. Macro-economic market and food chain effects are simulated by using the market model AGRISIM maintained at the University of Giessen. Three scenarios, involving different levels of restriction on azoles, are simulated and the impacts are assessed using a variety of different indicators. In addition, expert interviews were conducted with both farmers and technical advisors in one main winter wheat production region in the UK, France, Germany and Poland on the importance of azoles in the control of fungal plant diseases. These expert interviews provided data on expected yield losses which were used in the farm and sectoral simulations.

Results of the expert interviews

From the expert interviews it is clear that azoles are regarded highly by both farmers and technical experts for their role in combating disease in wheat production. Azoles are valued because of their effectiveness in maintaining yields and as part of a program of preventing the build-up of disease resistance. Restrictions on the use of azoles would have a dramatic impact for various reasons. Proper resistance management would become almost impossible. Disease control options would be significantly limited, leading to the inability to eradicate core diseases (septoria and fusarium) and higher disease levels. Average yields would decrease significantly (the suggested reductions ranged from 17% in Germany, 10-15% in the UK and 20% in France).

Within the azole class there are different active ingredients. When questioned, the experts, and particularly the technical advisors, ranked all active ingredients except for prothioconazole much worse than epoxiconazole. However, when the qualitative statements made by the interviewees were analyzed, it appeared that epoxiconazole was evaluated better than prothioconazole.

Results of the farm-level analysis

Impacts on costs and benefits of cereal farms in case of a ban of azoles and reduced fungicide application were calculated based on gross margin analysis. A standardized crop rotation with 33% winter wheat, 33% winter barley, 29% rape and 5% sugar beet is assumed for the calculation. Gross margins would decrease significantly in case of a ban of azoles (this is the extreme scenario analyzed and assumes that yields for each crop in the rotation would decrease by 25% with the exception of winter barley where yields are projected to fall by 6.5%. Under these assumption, gross margins would fall by -9% in the UK, by -11% in Germany and France, and by -21% in Poland). Taking fixed costs into account, net farm incomes would decrease even more significantly in case of a ban of azoles, and in this extreme scenario could threaten the existence of cash crop farms. The simulation estimates suggest net farm incomes could fall by -11% in France, by -17% in the UK, by -20% in Poland and by -29% in Germany.

Because a restriction or a possible ban on azoles would result in much less effective resistance management when combating fungal diseases in grain, profits in some years could be reduced by over 60% due to high yield fluctuations. Varying climatic conditions during the growing season require a curative fungicide to combat fungal diseases efficiently. Using only protective treatments would result in increased and more costly fungicide applications. Crop farms which are normally burdened with high fixed costs would find it difficult to absorb these profit fluctuations or respond to them. Decoupled direct payments do help to stabilize farm incomes in the case of increased yield fluctuations. However, if those payments were limited in future due to reforms in the framework of European agricultural policy beyond 2013, a simultaneous restriction on fungicide management would cause clear destabilization of crop farm incomes.

Results of the sectoral analysis

An EU ban of azoles would reduce EU production of wheat, oilseeds and sugar by 18% to 25% in the worst case scenario, while all other producers on world markets would see an increase both in their production volumes and in market shares.

The EU net trade position in the three commodities most involved (wheat, sugar and oilseeds) is heavily affected. The EU would change its trade status from a net exporter to a net importer for wheat and sugar and significantly increase its oilseed imports.

The total annual EU welfare loss in the case of a ban of azoles could be as much as USD 5.6 billion and would be mainly borne by producers. But consumers would also be negatively affected because prices of most crops and of white meat products would increase, and the combined loss to EU consumers and taxpayers would amount to an additional burden of USD 173 million.

Net-importing countries and consumers in developing countries would be negatively affected by world market price increases of 6% to 9% for oilseed and wheat and would experience overall welfare losses.

More land would be necessary to compensate for the yield losses in addition to that required to meet the food requirements of a growing population.

Key messages for policy makers

Risk management requires a socio-economic appraisal of the benefits from pursuing a course of action (in this case, introducing greater restrictions on or possibly banning the use of azole-based fungicides in crop protection) in comparison with the costs. This study does not attempt to measure any potential benefits to human health or the environment, but it does underline the potentially severe effects of further restrictions on the use of azoles on the economic viability of important elements of European agriculture.

Reliance on a narrow range of fungicidal products increases the likelihood of the appearance of disease resistance in other fungicides. The analysis shows the importance of maintaining as broad a spectrum of plant protection products as possible to avoid the growth of disease resistance. The azoles, and particularly epoxiconazole, are important because of their curative as well as protective properties. Maintaining access for farmers to these active ingredients will reduce the pressure to increase more than proportionately usage of other, less effective, substitutes.

At the farm level, the prohibition of azole-based fungicides will reduce significantly the profitability of a core component of EU agriculture, particularly in countries such as Germany where crop farmers have high fixed production costs. Because the severity of fungal disease attacks varies from year to year depending on weather conditions and other factors, farm income will also be less stable if azole-based fungicides are no longer available.

For European agriculture, in the most severe scenario of a ban on azole-based fungicides, reductions of 18% to 25% in the production of wheat, oilseeds and sugar can be foreseen. These production decreases will lead to lower exports and greater imports and will put upward pressure on already high global prices for these products, creating further difficulty for net-importing countries already struggling to finance high food import bills.

It is important to take these negative effects on European farming and food into account in arriving at an informed judgment on the appropriate response to managing pesticide risk. Policy makers must assess if indeed there are public health or environmental benefits which might justify such a damaging outcome for European agriculture.

1. Introduction

1.1 Background and goals of the study

The focus of this study is on the role played in crop protection by a particular group of active substances, the triazoles or, more simply, azoles. The azoles are a group of chemical compounds which are used to protect cereals and other crops from devastating key fungal diseases. Septoria and rust are the two main diseases that adversely impact the productivity of cereals. Azoles are critical to controlling septoria and rust and maintaining cereal productivity. Only a few classes of fungicides have shown to be as robust over many years of use as the azoles. Among the azoles, especially the value of epoxiconazole to the grower is emphasized by its frequent use in the major cereal growing countries in the EU.

Plant protection products are a vital part of the armory of modern agriculture in protecting crops against insects, rodents and fungi. However, plant protection products can also cause environmental damage such as water pollution and may present risks to human health. The use and application of these products is therefore strictly regulated under EU legislation.

The regulation of plant protection products in the European Union (EU) was first harmonized under Council Directive 91/414/EEC, which came into force on 26 July 1993. This established agreed criteria for considering the safety of active substances, as well as the safety and effectiveness of formulated products. The Directive set out a two-stage assessment system:

- harmonizing the process for considering the safety of active substances at an EU level, and once safety of the active substance had been established;
- allowing product authorizations to be considered at a national level using the established harmonized criteria.

It took some time to set up the harmonized technical requirements, but in 2001 the process began of reviewing the 1,000 or so active substances (used in tens of thousands of different plant protection products across the Union). By the time the process was completed in 2009, around 250 active substances had passed the EU harmonized safety assessment, meaning that each active substance had been shown to be safe in terms of human health, residues in the food chain, animal health and the environment. The majority of the substances were eliminated because dossiers were not submitted, were incomplete or were withdrawn by the industry.[1]

In 2006 the European Commission launched its Thematic Strategy on Pesticides designed to further reduce the risks from pesticides to humans and the environment as far as possible by minimizing or eliminating, where possible, exposure and by encouraging the research and development of less harmful, including non-chemical, alternatives.[2] The main elements of the Strategy are a Regulation to replace the pesticide authorization Directive 91/414/EEC and a new Sustainable Use Directive.[3]

The agreed Regulation (EC) 1107/2009 on pesticide authorization to replace Directive 91/414/EEC was published on 24 November 2009 and will apply from 14 June 2011. It will continue to harmonize plant protection products across the EU as well as introduce some new requirements, such as the introduction of hazard-based criteria, assessment of cumulative and synergistic effects, comparative assessment and endocrine disruption.[4] The agreed Sustainable Use Directive (2009/128/EC) was published at the same time as Regulation (EC) 1107/2009 establishing a framework for Community action to achieve the sustainable use of pesticides.

The process of reaching agreement on Regulation 1107/2009 was a difficult one. The agricultural industry argued that the Regulation could potentially lead to the loss of valuable active substances without any meaningful benefits to public health protection beyond those delivered by the existing risk assessment arrangements. A particular dif-

[1] See http://www.endure_network.eu/fr/about_endure/all_the_news/eu_and_pesticides_online_info_and_update. ENDURE is an EU network of excellence bringing together around 300 researchers in the fields of fields of agronomy, biology, ecology, economics and the social sciences committed to developing a holistic approach to sustainable pest management.

[2] COM (2006)372. The term "pesticides" is used in this Communication as a generic name to encompass all substances or products that kill pests, including both plant protection products (used mainly in agriculture) and biocides (used in non-agricultural sectors for purposes such as wood preservation, disinfection or certain household uses). However, the main focus of the Communication is on plant protection products.

[3] Other elements include a new Statistics Regulation and an amendment to the machinery directive (to enable certification of new spray equipment).

[4] UK Health and Safety Executive, *Regulation of plant protection products in Europe,* http://www.pesticides.gov.uk/approvals.asp?id=2310, accessed 1 March 2011.

ficulty arises in the case of active substances which might be judged to be endocrine disruptors because currently there is no official definition of an endocrine disruptor.[5] The final endocrine disruptor definition will be developed in the period between now and 2013, and thus the final number of active substances which might be banned based on this risk remains unclear.[6] Various interim definitions have been proposed but also heavily criticized as lacking a scientific foundation. If these interim definitions were to be applied, there is a possibility that important active substances cold be lost.

Parallel with the development of the new Regulation on plant protection products, a European Community Regulation on chemicals and their safe use (EC 1907/2006) entered into force on 1 June 2007 dealing with the Registration, Evaluation, Authorization and Restriction of Chemical substances (REACH).

These regulatory developments and the possible reclassification and prohibition of azoles would potentially have serious consequences for European agriculture. Previous estimates suggest there would be a significant reduction in yields particularly for wheat from a ban on azoles.[7] The negative effects would include damage to European agricultural productivity and well as its adverse effect on food production and imports; the latter given that through the proposed changes European farmers' competitiveness, compared to non-EU farmers, will be reduced.

Thus the objective of this socio-economic study is to simulate different scenarios in case of a prohibition/limitation of azoles, in order to assess the degree of damage and negative effects quantitatively and qualitatively for European agriculture. The purpose of the study is to create a better understanding among relevant stakeholders with regard to the importance of azoles for farmers and the food industry.

[5] An endocrine disruptor is a synthetic chemical that when absorbed into the body either mimics or blocks hormones and disrupts the body's normal functions. This disruption can happen through altering normal hormone levels, halting or stimulating the production of hormones, or changing the way hormones travel through the body, thus affecting the functions that these hormones control. See http://www.nrdc.org/health/effects/qendoc.asp#disruptor.

[6] See, for example, the discussion in the UK Pesticides Safety Directorate, *Revised assessment of the impact on crop protection in the UK of the 'cut-off criteria' and substitution provisions in the proposed Regulation of the European Parliament and of the Council concerning the placing of plant protection products on the market*, 2008.

[7] See Clark, J. et al, *Pesticide availability for cereals and oilseeds following revision of Directive 91/414/EEC; effects of losses and new research priorities*, Research Review No. 70, Home Grown Cereals Authority, UK.

1.2 Methodologies used

This study assesses the implications of a restriction on the availability of azoles for crop protection on two levels:

1. Impacts on farmers (farm business management)

2. Impacts on European agriculture (economic point of view).

Three scenarios are simulated to analyze the impacts of a ban/restriction of azoles according to these levels. Farm-level effects are demonstrated by estimating the impact on gross margins and farm net income. Sectoral market and food chain effects are simulated by using the market model AGRISIM maintained at the University of Gießen.

The **three scenarios** evaluated are:

Extreme-Scenario No. 1:	Ban of azoles, no substitute products available
Scenario No. 2:	Prohibition of azoles, substitute products available
Scenario No. 3:	Prohibition of epoxiconazole, substitute products available.

The **impacts on the two levels** are measured in each scenario using the following indicators:

1. Impacts on farmers (farm business management)
    - Impacts on gross margin of winter wheat taking account of crop rotation, the use of agricultural inputs and services as well as tillage;
    - Efficiency loss due to use of substitute product (lower crop yields, higher costs, lower effectiveness);
    - Impacts on operating results of crop farms.

2. Impacts on European agriculture (economic point of view)
    - Yield losses in European agriculture;

- Development of commodity prices;
- EU and international production effects;
- Increase of imports from non-European countries and decline of exports to non-European countries;
- Welfare effects (consumer surplus, producer surplus, tax payer burden).

The active ingredient epoxiconazole is mainly sold in Germany, France, UK, Poland and the Benelux states. Expert interviews were conducted with both farmers and technical advisors in one main winter wheat production region in UK, France, Germany and Poland (with an approximate sample of 20 per country) on the importance of azoles in the control of fungal plant diseases. These expert interviews provided data on expected yield losses which were used in the micro- and macro-level simulations.

2. Results of the expert interviews

Methodology:

The target group of the expert interviews were leading farmers (n = 49) with a minimum winter wheat cultivation area of 50 hectares and technical experts (n = 36) in Germany, France, UK and Poland, giving a sample size of 85 interviews. Face-to face interviews were conducted in Germany, UK and Poland and face-to face as well as qualitative telephone interviews in France. Interviews took place in September/October 2010.

The goals of the expert interviews were as follows:

- To understand the relative importance of different active ingredients (AI) in wheat fungicide programs with a special focus on the importance of azoles;
- To evaluate the strengths and weaknesses of epoxiconazole vs. other AI's ("benchmarking");
- To assess the impact of stricter requirements of the European authorities on the usage of azoles.

Table 2.1: Sample distribution

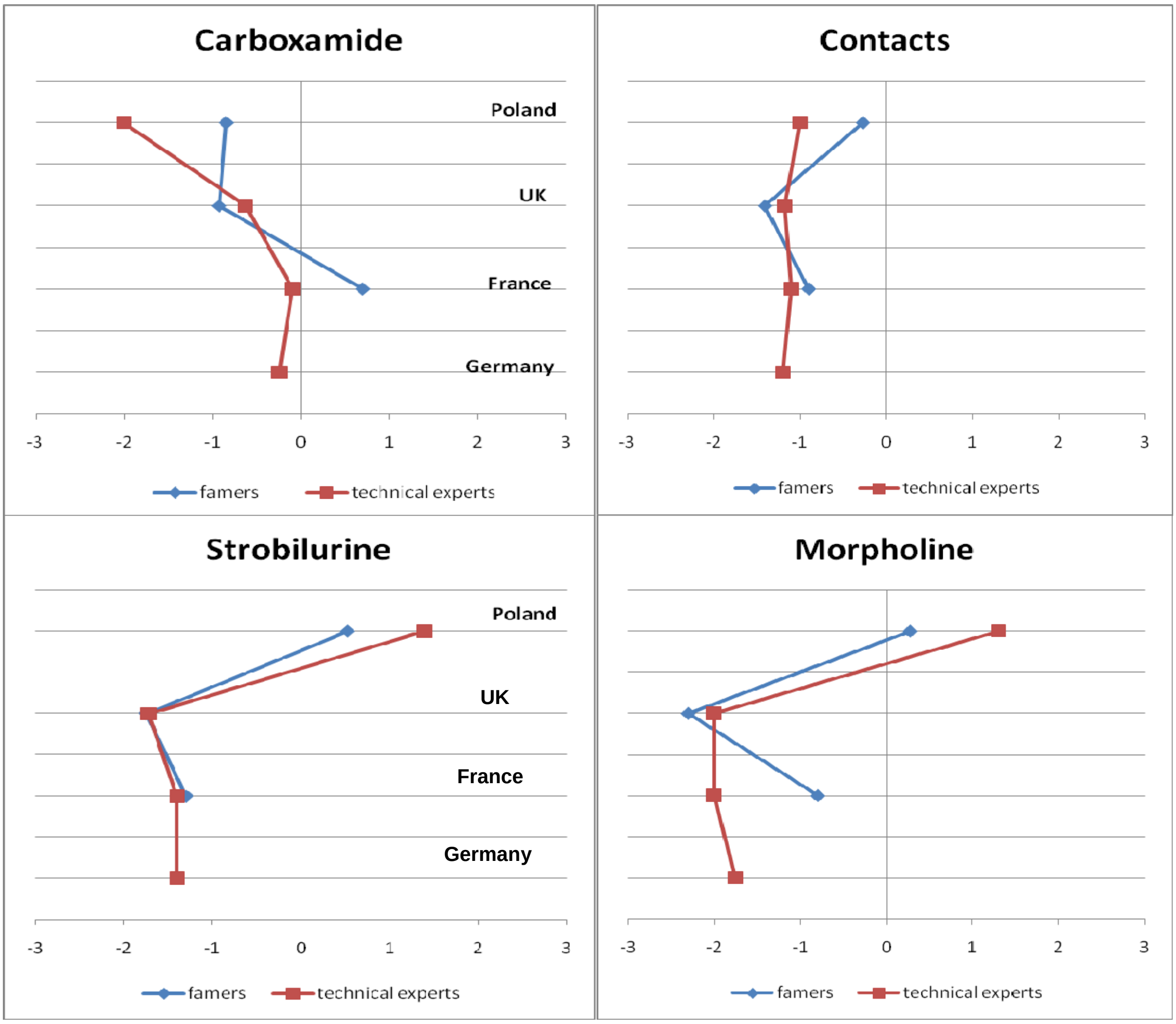
Country	**Number of Interviews**
Germany	20 (13 Farmers/7 Technical Experts)
France	20 (12 Farmers/8 Technical Experts)
UK	23 (12 Farmers/11 Technical Experts)
Poland	22 (15 Farmers/7 Technical Experts)
Total	**85**

The questionnaire was divided into four main parts and the interviewees were asked to:

a) benchmark different chemical classes;
b) evaluate the azoles;
c) benchmark different active ingredients (AIs) (focus on epoxiconazole);
d) evaluate possible responses due to new regulations and to provide information about farmer reactions in case of stricter regulations.

a) Benchmarking different chemical classes

Figure 2.1: How effective do you judge azoles in comparison with other types of chemical classes?



Scale: -3 = much worse than azoles, 0 = as good as azoles, 3 = far better than azoles

In general, farmers and technical experts judge azoles to be far better than other chemical classes except for Poland, where farmers and technical experts judge strobilurins and morpholines much better than azoles. The fact that resistance to strobilurins and morpholines is still low in Poland could be one reason for that positive evaluation.

In Germany, farmers as well as technical experts assess the (future) importance of azoles very favorably; key statements were "will continue to be very high, not replaceable, have highest impact on plant health and yields with regard to resistance management, curative action and broad spectrum". The (future) importance of carboxamides is also judged positively, “will increase on the market, ‘icing on the cake’, important mixing partner of azoles related to an efficient resistance management, length of control, safe effect”, but the high resistance risk of the carboxamides as a “single-site-active ingredient” was often mentioned.

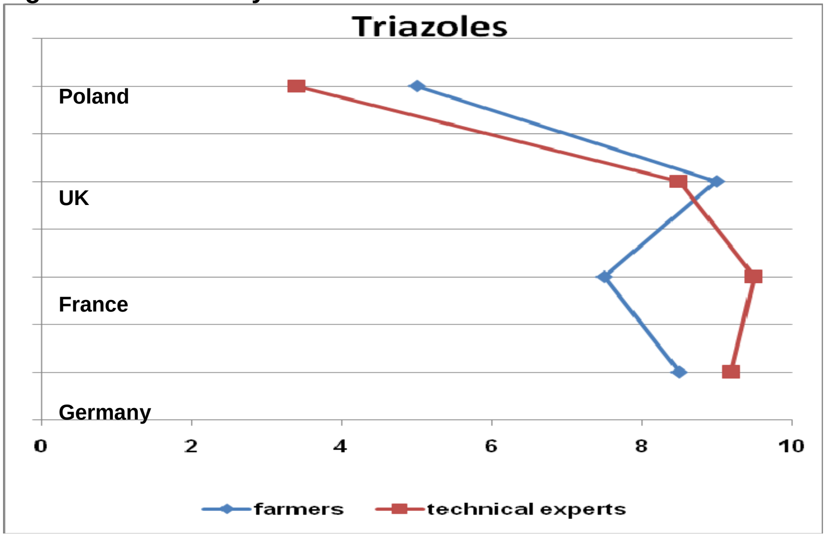
French farmers and technical experts also evaluate the (future) importance of azoles very highly. They state that azoles will “continue to dominate the fungicide program, have a very high importance, a broad spectrum, are best on septoria and fusarium, have a curative action and that their quality/price ratio is very good”. With regard to the carboxamides especially French farmers have high expectations for this new chemical class which they state as “good value for money, convenient, light but steady progress and an innovation”. Technical experts are a bit more critical and expect that carboxamides “may reach their plateau soon, maybe soon new variations, if not – collapse in 5 years”. Both farmers and technical experts agree with the fact that carboxamides imply an “interesting spectrum against e.g. septoria or eyespot” and are a “good tool to cope with resistance in synergy with the leading azoles”. Both groups mentioned also the resistance risk of carboxamides and that they need a complement due to this.

In UK, both groups stated that azoles will maintain a “very high importance in future, are a very crucial chemical because of its all-round capabilities and critical role for eradication activity on septoria, are still the base for every fungicide program and essential to keep resistances down”. Farmers in UK have “great hopes in the new chemical carboxamides, but pointed out that their usage will depend on the price”. Technical experts judge the carboxamides as a “new product but promising with rising importance and a good partner for the azoles”. Both groups note critically the “limited spectrum of diseases and the high price” of azoles.

As already mentioned, Polish farmers and technical experts judge strobilurins and morpholines better than azoles likely due to a lower build up of resistances in the country. The importance of strobilurins is evaluated “as very high and constant, long impact duration, high impact activity”. Morpholines will maintain a “medium to high importance with a quick impact”; one advantage is the “possible application at low temperatures”. The future importance of azoles is judged as “mainly high due to their quick impact and broad spectrum”. No conclusions were drawn with regard to the (future) importance of the carboxamides which is likely due to the fact that they are not used so far in Poland.

The fact that the high resistance risk of carboxamides is already known in all countries, even though they are very new on the market, should be underlined.

Figure 2.2: How easy is it to substitute the different chemical classes?



Scale: 0-10, 0= very easy to substitute, 10 = very difficult to substitute

Farmers and technical experts in all countries apart from Poland underlined the difficulty to substitute for the azoles. One can assume that the lower rating for azoles in Poland is due to a higher efficacy of strobilurins there to date. This statement is confirmed when taking a look at the high rating for strobilurins (same question) in Poland. Carboxamides are classified more in the middle of the rating scale. It is possible farmers and technical experts had difficulties to estimate the impacts of an absence of this chemical class due to their recent availability.

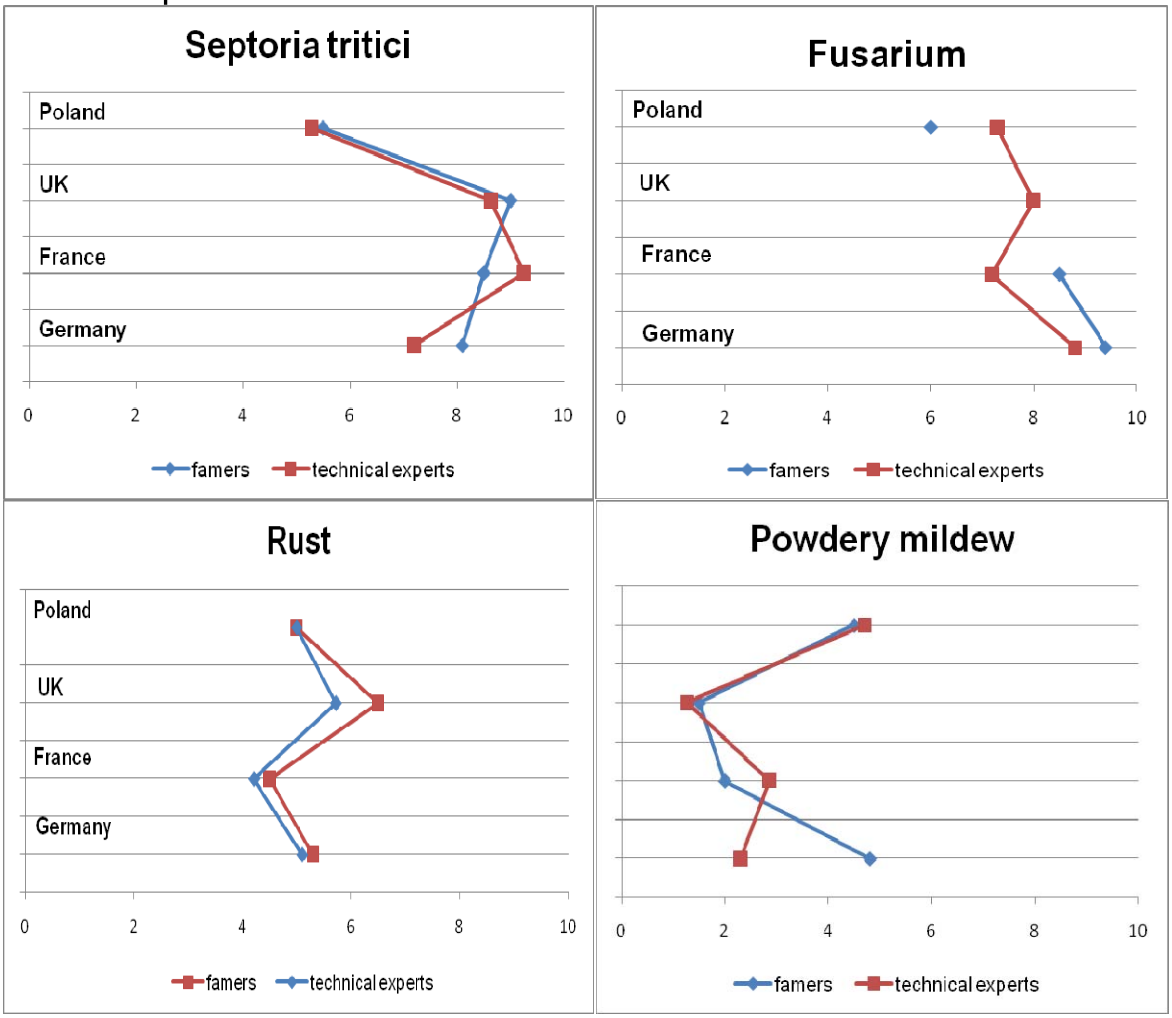
Table 2.2: How easy is it to substitute carboxamides and strobilurins?

	Carboxamides Ratings
Poland	-
UK	6
France	6
Germany	4.4
	Strobilurins Ratings
Poland	8
UK	5
France	3
Germany	3

Scale: 0-10, 0= very easy to substitute, 10= very difficult to substitute, calculated averages from farmers and technical experts statements

b) Evaluating the azoles

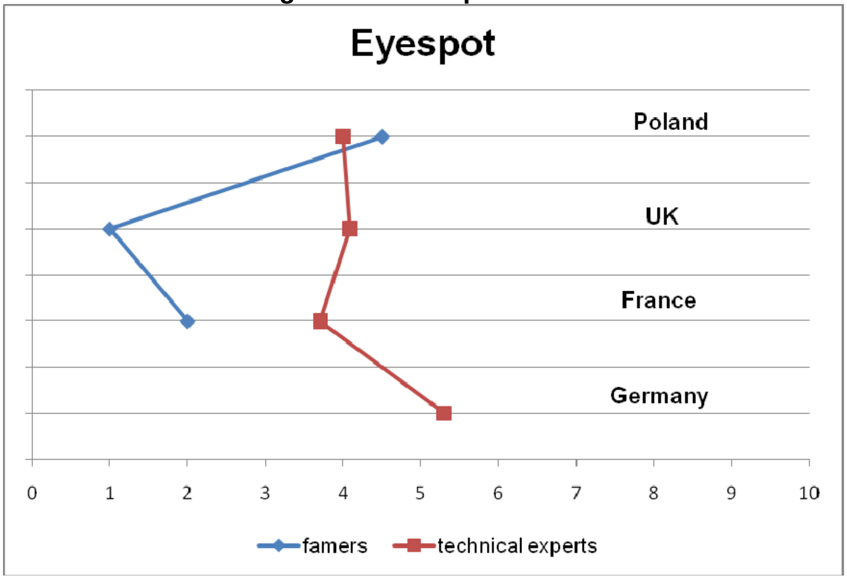
Figure 2.3: Do you think it would be possible to combat the following diseases without using azole-based products?



Scale: 0-10, 0 = very easy to combat without azoles, 10 = extremely difficult to combat without azoles

The charts make clear that farmers and technical experts in UK, France and Germany would find it very difficult to combat fusarium and septoria tritici especially without azole-based products. Only Polish farmers and technical experts do not foresee such a severe problem in combating septoria tritici without azoles. With regard to rust, farmers and technical experts agree on a rating between 4 and 6.5. As to powdery mildew opinions differ slightly. Farmers and technical experts in UK and France as well as German technical experts assess the combating of mildew without azoles as easier than do German farmers as well as Polish farmers and technical experts. Concerning eyespot, Polish, English and French farmers would find it easier to combat it without azoles than technical experts in these countries as well as both farmers and technical experts in Germany, who judge it more difficult.

Figure 2.4: Do you think it would be possible to combat the following diseases without using azole-based products?



Scale: 0-10, 0 = very easy to combat without azoles, 10 = extremely difficult to combat without azoles

Question: In your opinion, what influence would a restriction on the availability of azole-based products have on resistance management, disease control and yields?

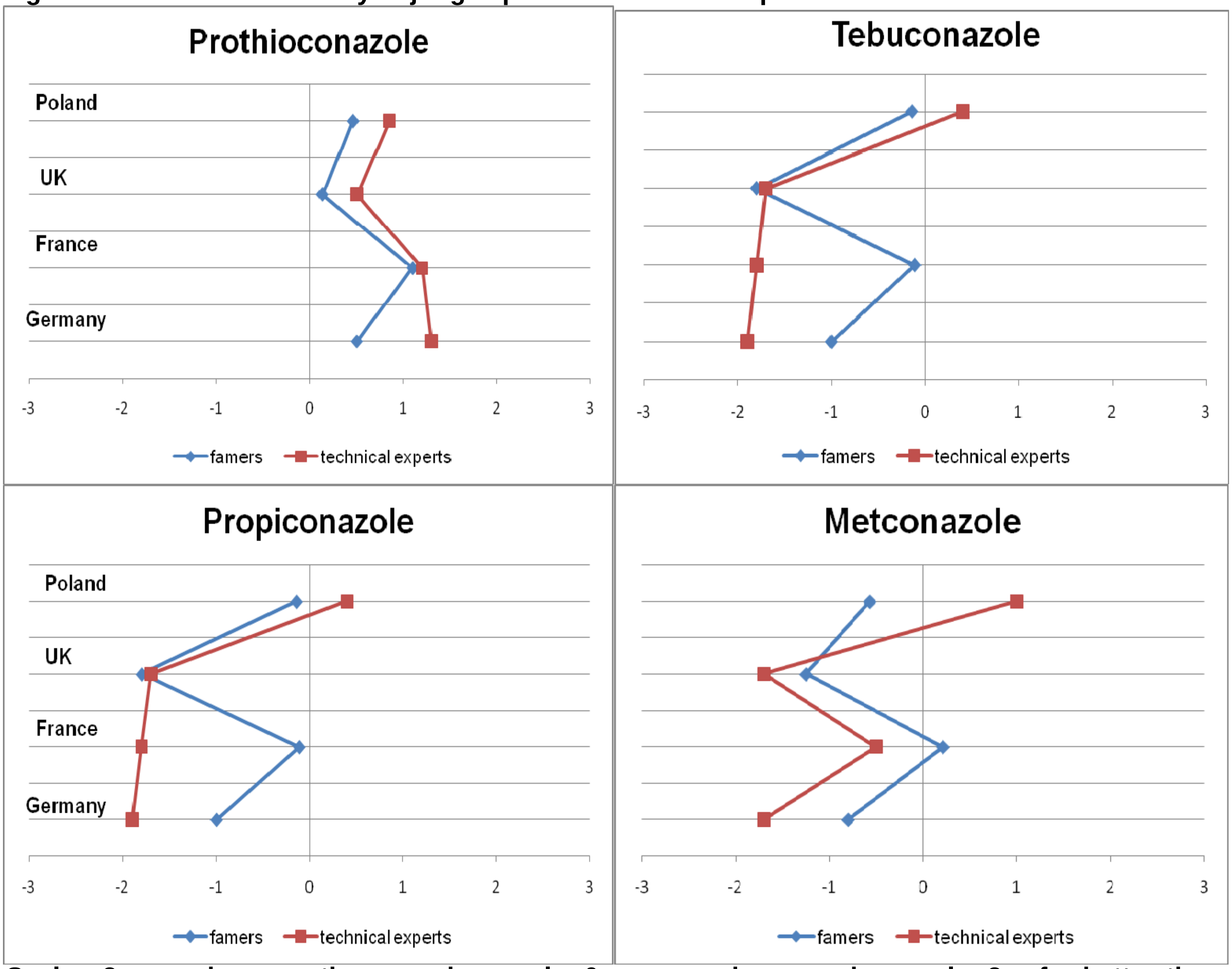
There is a strong consensus among all countries that a restriction of azoles would have a dramatic and disastrous impact on **resistance management**. German farmers and technical experts both state that "resistance management without azoles would become extremely difficult or almost impossible, restriction of azoles would increase resistances and raise the biggest problems with septoria; furthermore without azoles integrated pest management and prophylactic work must be practiced more intensely." Key statements from French farmers and technical experts concluded that "it will be impossible to work without azoles and that efficacy, convenience, flexibility as well as quality will be reduced and costs and the number of treatments will increase." English farmers and technical experts also expect a "huge and disastrous impact on resistance management because a restriction of azoles will largely limit the disease control options, thus proper resistance management would become almost impossible or at very high costs". A bigger part of Polish farmers and technical experts expect "a high impact on the resistance management and expect that resistances of mycosis will grow".

There was also a strong consensus in Germany, France and UK that a restriction of azoles will have a strong influence on **disease control**. German farmers and technical experts indicated that a restriction of azoles would have a “strong influence on disease control due to resistance building, increased disease pressure, complicated disease control due to missing curative effects, higher costs, more time consuming and strongly limited treatment possibilities”. French farmers and technical experts would expect a “strong influence but only on septoria and fusarium due to a loss of efficacy; other products in association or in sequence will enable the growers to efficiently control rusts, powdery mildew and, to a lesser extent, eyespot.” English farmers and technical experts specified that “disease control without azoles will be much harder and disease levels would be much higher (+ 50%), they expect a poor and unreliable control of core diseases, an inability to eradicate established diseases (septoria!), reduced efficacy and that disease control will be more costly.” Polish technical experts also expect a “wide influence on disease control” due to a restriction of azoles, while the bigger parts of Polish farmers expect only “a low impact”.

Farmers and technical experts in all countries agreed that a restriction of azoles would lead to a significant **yield decrease**. The level of the stated yield decrease in Germany ranged between 5-30% (average 17%). French farmers and technical experts estimated the loss of yield potential to amount to 20% and said that the impact on margins and profitability would be dramatic. Farmers and technical experts in UK rated the yield decrease would amount to 10-15%. They also highlighted increasing costs, a loss of profitability, that farming would become unsustainable and that the yield decrease could affect the suitability for specific markets. Farmers and technical experts in Poland just affirmed that yields would decrease due to a restriction of azoles without quantifying their statements.

c) Benchmarking different active ingredients (AIs) (focus on epoxiconazole)

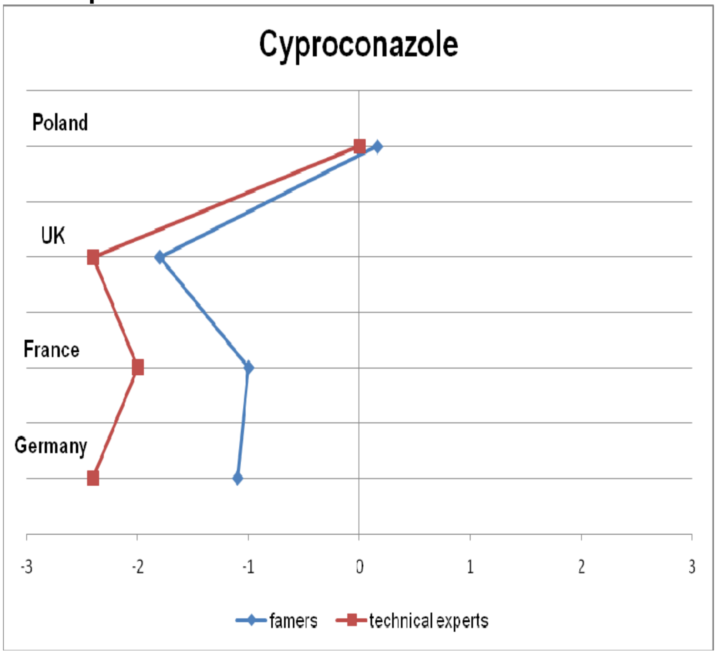
Figure 2.5: How effective do you judge epoxiconazole in comparison with other AIs of the azoles?



Scale: -3 = much worse than epoxiconazole, 0 = as good as epoxiconazole, 3 = far better than epoxiconazole

The charts illustrate very well that only prothioconazole is judged better than epoxiconazole by all countries. All other active ingredients are judged much worse than epoxiconazole, especially by technical experts in all countries except for Polish technical experts, who judge tebuconazol, propiconazole and metconazole (slightly) better than epoxiconazole. French farmers judge metconazole slightly better than epoxiconazole, Polish farmers cyproconazole.

Figure 2.6: How effective do you judge epoxiconazole in comparison with other AIs of the azoles?



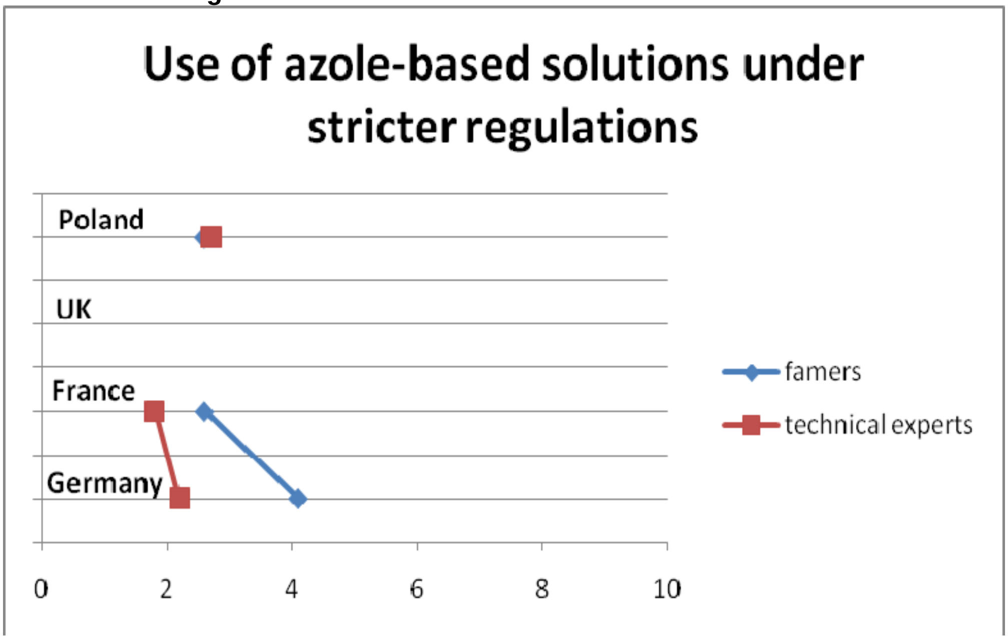
Scale: -3 = much worse than epoxiconazole, 0 = as good as epoxiconazole, 3 = far better than epoxioconazole

Technical experts in all countries except for Poland judge tebuconazole, metconazole, propiconazole as well cyproconazole much worse than farmers in these countries. Concerning prothioconazole, the situation is reversed because it is judged better by technical experts in all countries. Another question covered especially the strengths and weaknesses of epoxiconazole compared to prothioconazole. It is interesting that farmers as well as technical experts highlighted in particular many advantages of epoxiconazole compared to prothioconazole, which was not expected due to the ratings given before. German farmers and technical experts highlighted a better curative effect and better efficiency against rust as an advantage of epoxiconazole over prothioconazole. French farmers and technical experts rated epoxiconazole "a brilliant efficacy against septoria and rust, an excellent price-quality ratio, a better curative effect, a great comfort in utilization and a flexible dosage" compared to prothioconazole. Very similar statements with regard to the advantages of epoxiconazole over prothioconazole are made by farmers and technical experts in UK, who term epoxiconazole "better on rust, best curatively among all chemicals, easier to use and flexible regarding dose rates". French and German farmers and technical experts judge prothioconazole "more efficient against fusarium and eyespot and a better long impact" (the latter only in Germany). Farmers and technical experts in UK judge prothioconazole "better against eyespot and powdery mildew". One possible reason for the better evaluation of epoxiconazole concerning the qualitative statements could be a stronger disease pressure with regard to fusarium and eyespot in Germany and France as well as eyespot and powdery mildew in UK, but there is no evidence for these assumptions.

d) Possible changes in product use due to new regulations in the future

Almost all interviewees in the countries are aware of the revision and update of the EU Directive 91/414 and potential further restrictions of the azoles class. Most of them know that this restriction is likely to affect epoxiconazole. Technical experts in Germany state that the proposed revision of Directive (91/414/EWG) and tighter criteria for authorization contained in the new Regulation 1107/2009 as well as the possible reclassification of epoxiconazole would have serious consequences on farmers as well as European agriculture. They think those requirements are exaggerated. Technical experts in France argue that the new directive applied with no flexibilities to all azoles would make wheat cultivation almost impossible. Experts in UK asserted that any restriction would lead to a huge reduction in the flexibility of programs. Restrictions on the application window and number of applications would have possibly the biggest impact in some circumstances as it effectively removes the product from use for certain purposes. Possible reductions in rates, restricted tank mixing (dose restrictions) and also a restriction on the area where the chemicals can be applied because of water quality will further affect farmers. Polish experts expect that prices will increase because of a decreasing number of products, the costs of application and crop growing will increase, resistances will increase because of lower diversity of products and yields will decrease because of more diseases. Asked how a restriction of azole-based products would affect their planting habits, most farmers in Germany say that they can imagine adapting their crop variety due to this restriction. But this would require a shift of prices in favor of competing products to wheat. French farmers state that they will not change their planting habits as a consequence of stricter regulations. They will only be influenced by macroeconomic factors like the cereal price etc. They will continue to evolve agronomic practices, to monitor and to fine-tune their disease management programs which are based on azoles. Farmers in UK feel that a restriction at this stage because of unproved reasons without equivalent substitutes is unnecessary and irresponsible in the long-term because of pressure on resistance management due to fewer options and increased use of less environment-friendly remaining chemicals. They expect that a restriction will lead to more costly disease control because new products will be more expensive and the number of applications will increase. They also expect a drop in yields. Furthermore, farmers stated that if the azoles class is restricted they would need to look for cleaner wheat varieties which also lead to lower yields. Most of the Polish farmers state that they would not change their planting habits due to stricter regulations.

Figure 2.7: Would you be prepared to use/would you still recommend azole-based products under stricter regulations?



Scale: 0-10, 0 = use/recommend like before, 10 = not use/recommend them at all anymore

The graphic illustrates that farmers as well as technical experts would still use or recommend azoles-based products under stricter regulations. Farmers in Germany will still use azoles but it depends on existing alternatives and degree of stricter regulations. Cereal growers in France are ready to face many inconveniences to “save” the azoles. They realize that programs will more and more have to be complemented by ongoing changes in agronomic measures. If good agronomic practices are not supported by an adequate product portfolio, cereal cultivation will soon become impossible. Farmers in UK found it difficult to rate a future use of azoles against a scale. Instead they responded that first it needs to be clear what the restrictions will be. Then they will look over their spraying program and make adjustments in order to maintain their yields. As long as they are allowed to use azoles and if it is still practical in terms of costs, farmers will continue to use them.

German technical experts will recommend azoles as long as it is acceptable for farmers given the lack of alternatives and that it is impossible to practice resistance management without azoles. They state that in general farmers' pain barrier is very high. French technical experts comment that in case of tougher restrictions disease management is likely to become a nightmare, a mission impossible. Technical experts in UK state that under stricter but reasonable regulations they will without any doubt continue to advise azoles. However, it will depend on the severity of the restrictions and on the region. Programs have to be planned very carefully. In general as long as it is practical in terms of costs, returns and efficiency azoles will be recommended to the maximum allowable.

3. Results of the farm business analysis

Impacts on costs and benefits of cereal farms in case of a ban of azoles and reduced fungicide application were calculated based on gross margin analysis. A standardized crop rotation with 33% winter wheat, 33% winter barley, 29% rape and 5% sugar beet is assumed for the calculation.

Yield and price

Yields [dt/ha] and prices [Euro/dt] for wheat, barley and rape were estimated using the mean values of 2005 to 2009 (Tables 3.1 to 3.4).

Table 3.1: Yield and Price for cereal, rape and sugar beets in Germany (mean 2005 to 2009, sugar beets only 2009)

		wheat	barley	rape	Sugar beet
Price	Euro/dt	13,59	12,53	26,82	2,63
Yield	dt/ha	75	65	38	619

source: Eurostat

Table 3.2: Yield and Price for cereal, rape and sugar beets in France (mean 2005 to 2009, sugar beets only 2009)

		wheat	barley	rape	Sugar beet
Price	Euro/dt	14,02	11,36	27,56	2,63
Yield	dt/ha	69	65	33	852

source: Eurostat, Agreste

Table 3.3: Yield and Price for cereal, rape and sugar beets in UK (mean 2005 to 2009, sugar beets only 2009)

		wheat	barley	rape	Sugar beet
Price	Euro/dt	14,55	12,65	26,90	2,63
Yield	dt/ha	79	65	33	612

source: Eurostat, Defra Statistics

Table 3.4: Yield and Price for cereal, rape and sugar beets in Poland (mean 2005 to 2009, sugar beets only 2009)

		wheat	barley	rape	Sugar beet
Price	Euro/dt	13,75	12,87	25,92	2,63
Yield	dt/ha	39	38	28	475

source: Eurostat

By means of the multi-product-multi-region model AGRISIM (see chapter 4) price changes in case of a reduction of production output were determined (Table 3.5).

Table 3.5: Price increase due to yield reductions - results from the model AGRISIM

yield reductions	price increase in %			
	wheat	barley	rape	sugar beets
-5%	1,69	0,72	1,17	0,17
-10%	3,44	1,45	2,38	0,35
-15%	5,25	2,20	3,63	0,53
-20%	7,14	2,96	4,92	0,72
-25%	9,10	3,74	6,26	0,91

Source : own results

Plant protection

Costs for crop protection products in the gross margin analysis are based on the *European arable crop profit margins (EACPM) 2008/2009*[8]. Costs for fungicide application are based on expert statements of leading farmers in France, Poland, UK and Germany. The same also applies for information about percentage of azoles on fungicides (Table 3.6).

[8] BROOKES, G.: European arable crop profit margins 2008/09, 6th edition, Gloucestershire, 2010.

Table 3.6: Fungicide application in wheat

		France	Poland	UK	Germany
		n=12	n=8	n=12	n=9
plant protection (EACPM)	Euro/ha	123	73	168	128
fungicide	Euro/ha	75	64	106	89
azole-based plant protection	Euro/ha	56	28	96	70
fungicides fraction from plant protection	%	61	88	63	70
Azole fraction from fungicides	%	75	43	90	78

Sources: European arable crop profit margins 2008/2009 (EACPM)
Results expert interviews

Profit margins in case of a ban of azoles were calculated for three scenarios (see table 3.7) under the assumption of yield reductions between -5 to -25%.

Within each crop rotation the same yield reductions were assumed based on the conducted expert interviews, since with the increase in oilseeds area due to an increasing demand in Europe for oilseeds to be used for biodiesel production, the infestation pressure with Phoma lingam and Sklerotinia sclerotiorum in rape will also increase. For sugar beet the same yield reductions were also assumed, since azoles are necessary in seed coating or pelleting of sugar beet against blackleg of beet as well as to combat Cercospora.

Based on the data collection on yield reduction and the conducted expert interviews only a lower yield reduction is assumed for winter barley (table 3.7), which leads to smaller profit margin changes for winter barley within the scenarios.

Table 3.7: Yield reductions in the respective scenarios under the assumption of a ban of azoles

scenario	no.	yield wheat, oilseed, sugar	yield coarse grain
1 Azol ban no substitute	1a	-25%	-6,25%
	1b	-20%	-5,00%
2 Azol ban substitute available	2a	-15%	-3,75%
	2b	-10%	-2,50%
3 Epoxiconazole ban substitute available	3a	-5%	-1,25%
	3b	0%	0%

Sources: LK Hannover: Results of variety trials in winter wheat, Year 2005 to 2009, Test schemes reports.
LfL Bavaria: Variety trials in winter wheat, Year 2005 to 2009.
Own analysis and results.

Gross margin impacts in Germany, France, UK and Poland

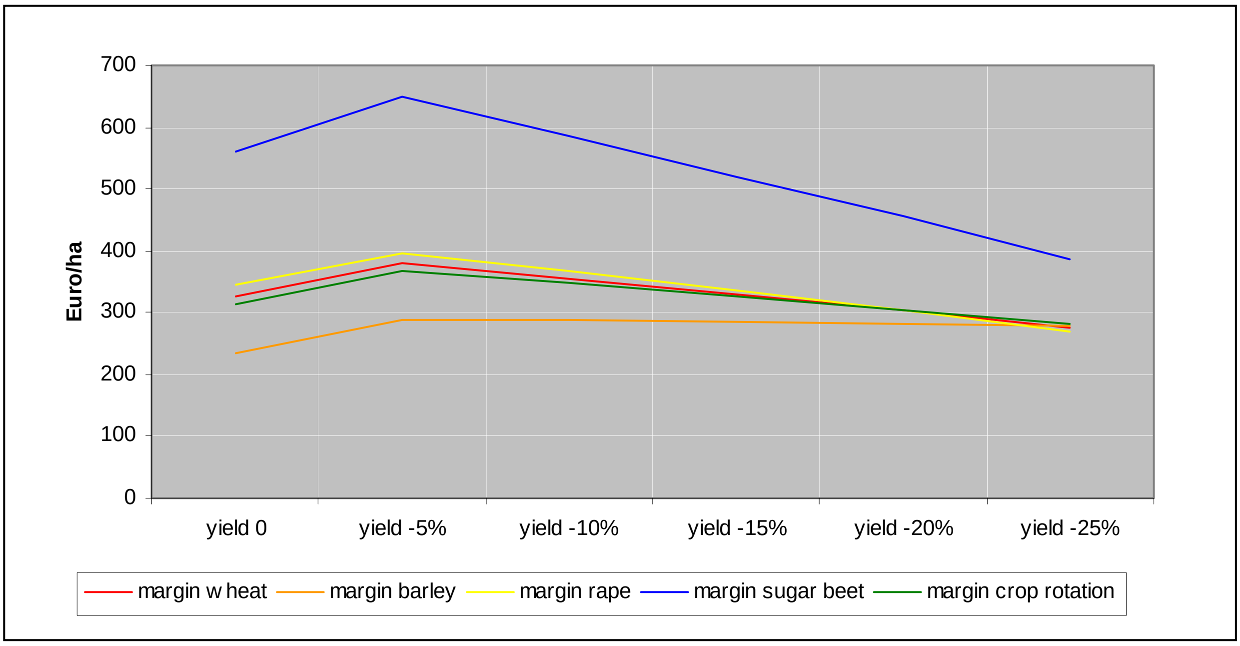
Gross margins of all analyzed crops are negatively affected in case of a ban of fungicides and under the assumption of yield reductions between -10 and -15%.

If lower yield reductions than 10% occur due to a ban on azoles, then an initial positive development of gross margins is observed due to reduced costs for azole-based fungicide application. This cost saving would have a positive effect in the case of yield reductions up to 10% given the assumed yields and effects of yield changes on commodity prices. With greater yield reductions the lower output would lead to gross margin losses (Fig. 3.1 to 3.4). Higher yields and commodity prices than currently achieved on the market lower this positive effect and would lead to gross margin losses even in the case of relatively small (<-10%) yield reductions. For crop farms, it remains rational to apply azole-based fungicides even if the yield gain were assumed to be small, in part because the early partly protective application of fungicides is a crucial element for yield stability and in part because an individual farmer cannot assume there would be a countervailing increase in commodity prices if he or she alone were to abstain from using these products.

Noticeable is that the gross margin of winter barley would increase by around 20% in all scenarios. Here, increasing prices for coarse grain compensate for a lower yield reduction in case of an abandonment of fungicides. Yield reductions for all other crops are not balanced through increasing prices.

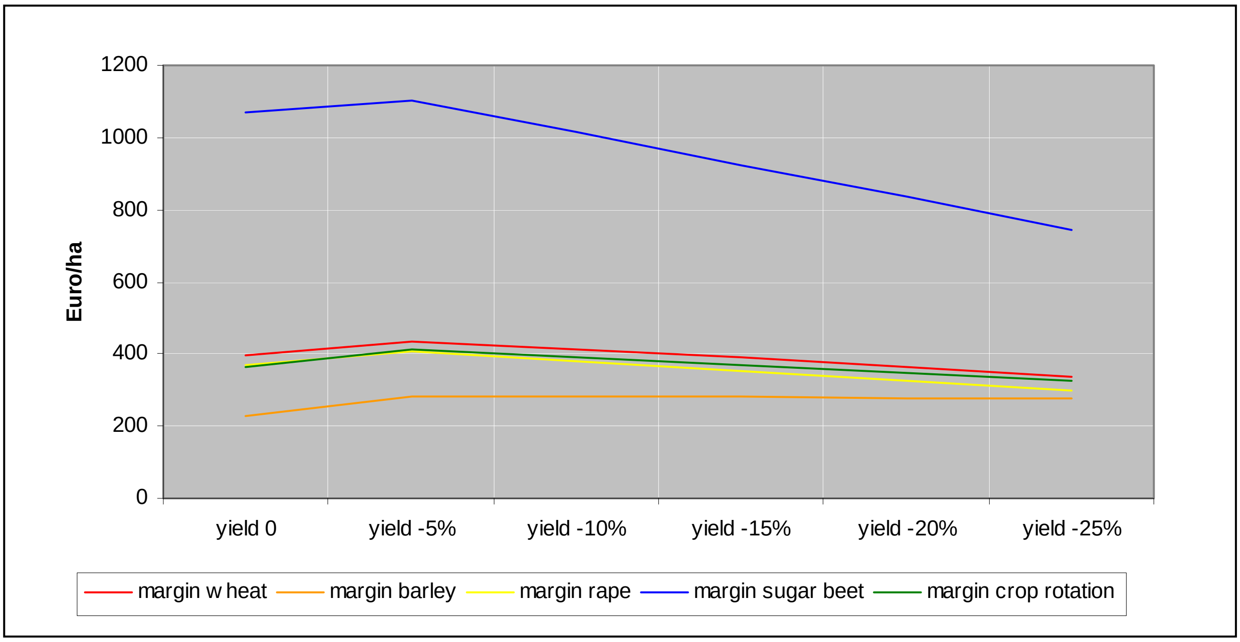
Poland with marginal yields (39 dt/ha) in the case of wheat returns a rather low gross margin. The non-application of azoles considerably reduces the advantage of rapeseed over wheat. A ban on azoles application even where the yield reduction is only 5 to 10% already leads to losses in gross margin.

Figure 3.1: Change of gross margins due to a ban of azoles in Germany



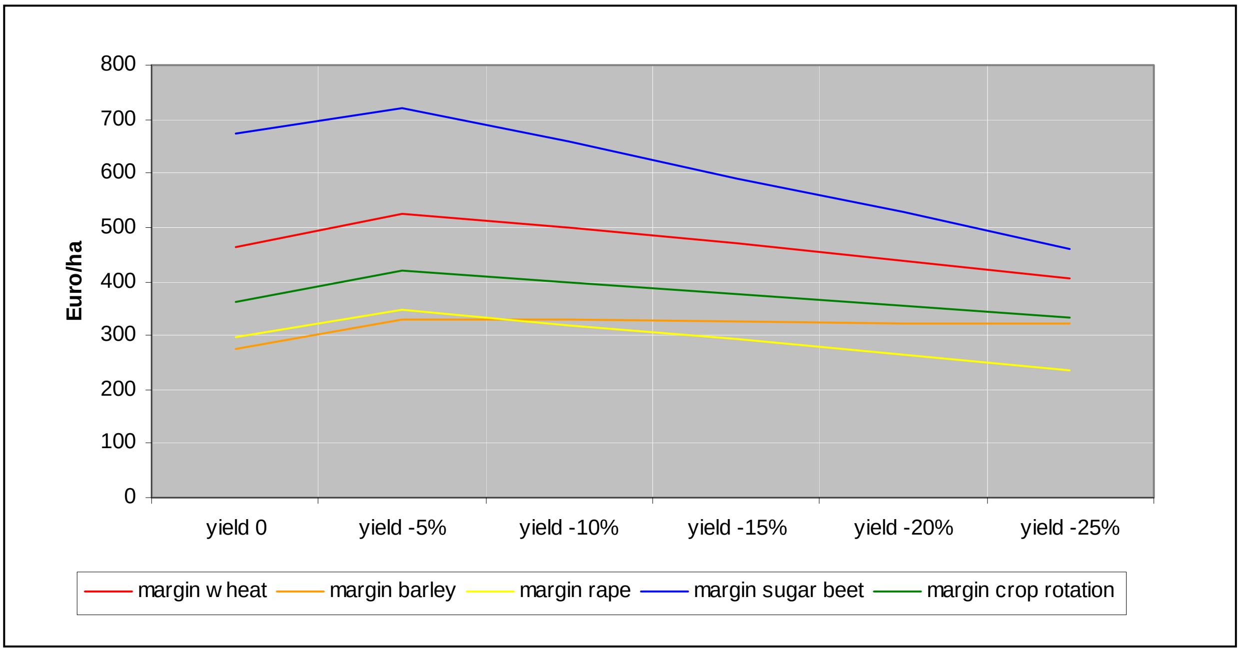
Source: own results

Figure 3.2: Change of gross margins due to a ban of azoles in France



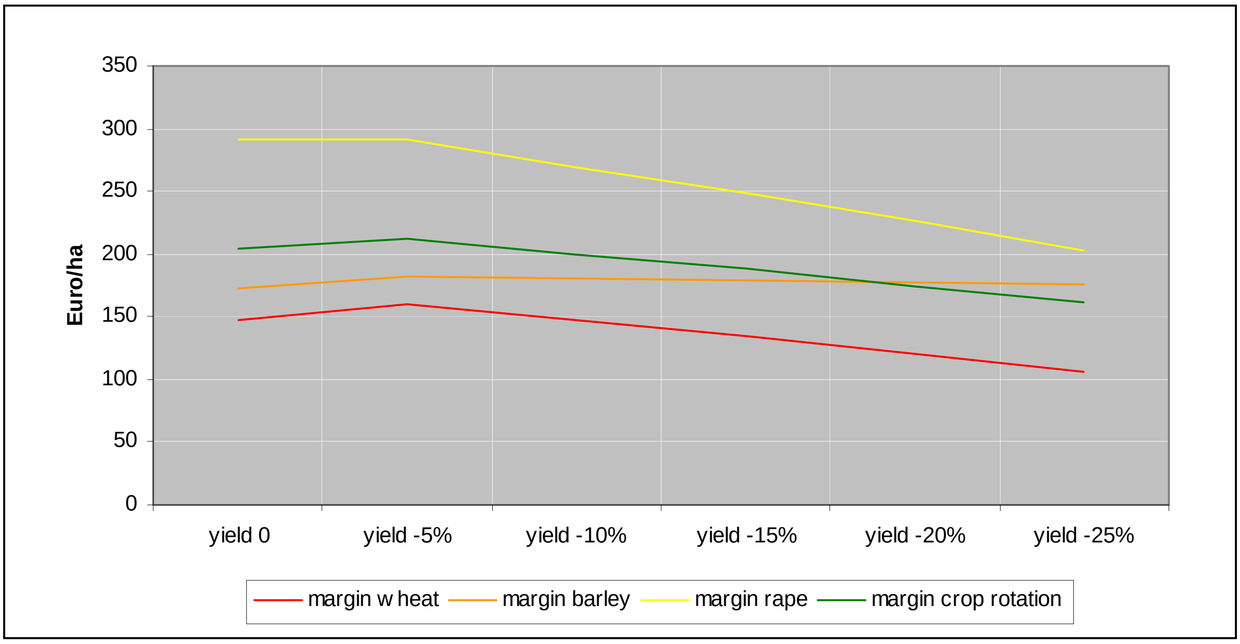
Source: own results

Figure 3.3: Change of gross margins due to a ban of azoles in United Kingdom



Source: own results

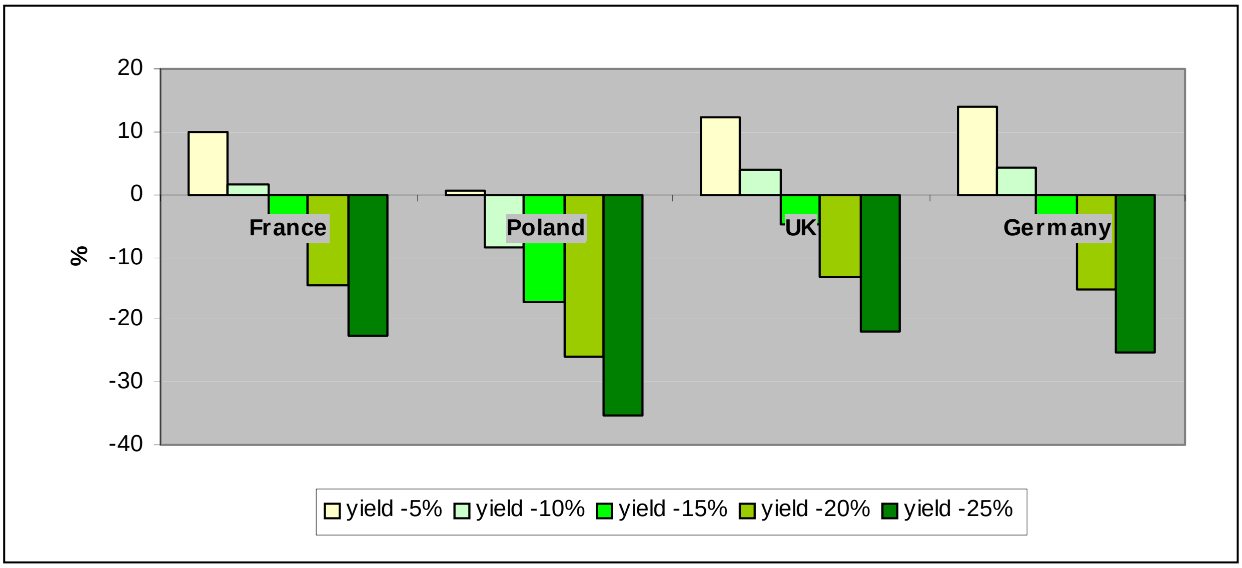
Figure 3.4: Change of gross margins due to a ban of azoles in Poland



Source: own results

A loss of azoles within agricultural production in the absence of an equally effective substitute has clearly different impacts on gross margins in the analyzed countries. Due to low yields in Poland, gross margins [Euro/ha] after deduction of variable costs are also low. Accordingly, a given yield decrease [in %] affects gross margins more heavily than in countries with higher yields [dt/ha]. Poland with a low gross margin is notably affected by yield reductions caused by the non-application of azoles with losses in gross margin up to 20% (Fig. 3.5).

Figure 3.5: Change of gross margins (crop rotations) due to a ban of azoles



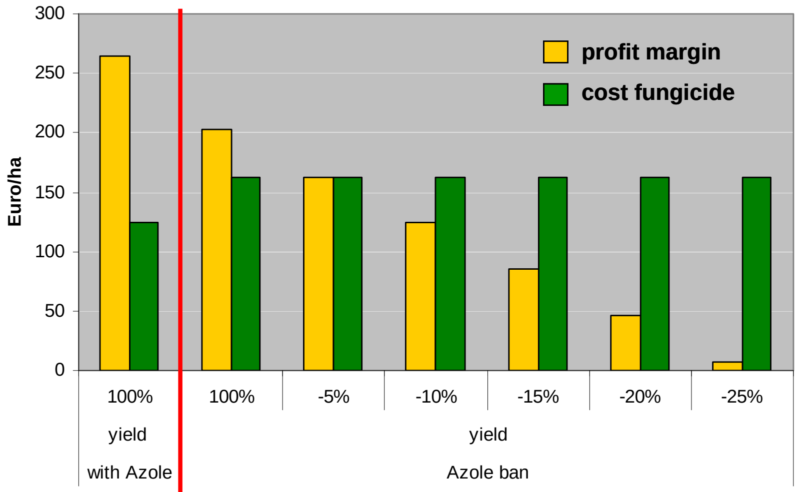
Source: own results

Temporary substitution of azoles through strobilurins

Substitution of azoles through strobilurins leads to considerable resistance problems already after a short time period. Moreover, azoles have a curative effect, whereas strobilurins have to be applied several times due to their protective effect only. Assuming a medium to high disease pressure alternatives based on strobilurins would cause an increased fungicide application and strong decrease in gross margins. Yield reductions amounting to over 20% caused by resistance would cause decreases in gross margins to below 50 Euro/ha (Fig. 3.6).

Figure 3.6: Change of gross margins from winter wheat due to a ban of azoles and substitution through strobilurins in Germany

crop protection strategy for average to high fungus outbreak:
- **mildew**
- **Septoria tritici**
- **DTR**
- **leag rust (süd/west Deutschland)**
- **spike fusariose**



with Azoles (curative)			w/o Azoles (protective)		
product	**active substance**	**l/ha**	**product**	**active substance**	**l/ha**
1x Champion+Diamant	Epoxiconazol, Pyraclostrobin	1,75	2x Bravo 500	Chlortalonil	2,50
1x Vergas	Cyflufenamid	0,20	1x Vergas	Cyflufenamid	0,20
1x Prosaro	Pronthioconazol, Tebuconazol	1,00	2x Amistar Opti	Azoxystrobin, Chlortalonil	2,50
			1x DON Q	Thiophanat-methyl	1,10

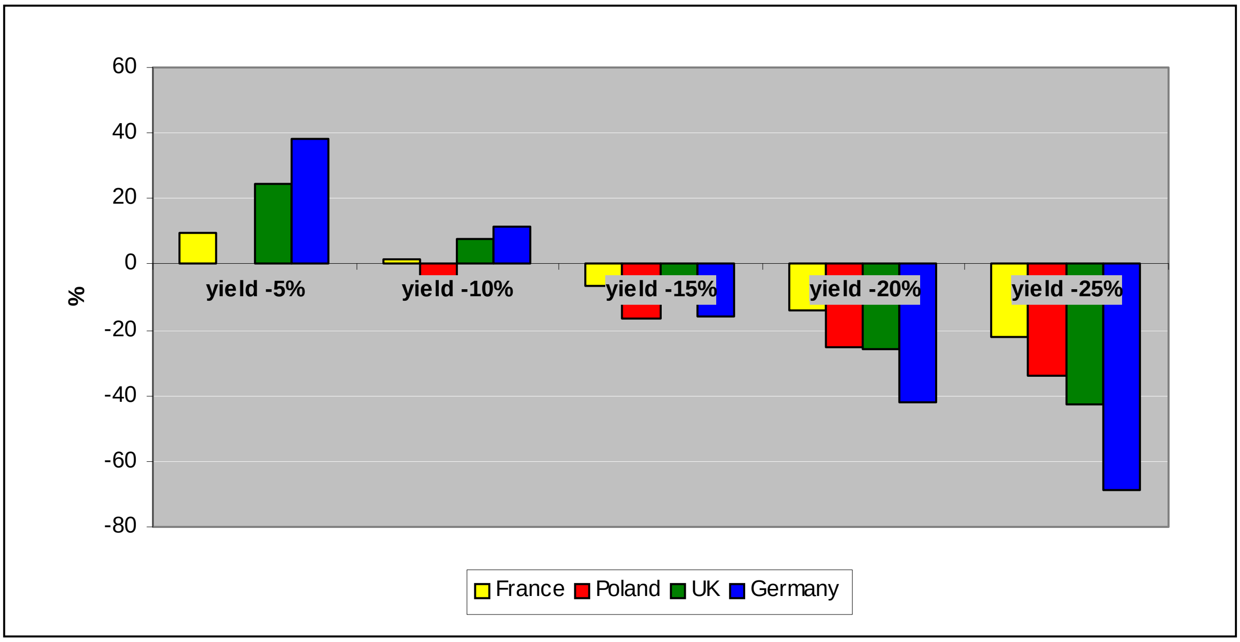
Source: own results

Farm net income in cereal farms

Impacts on farm net incomes are determined based on gross margins contained in a specific analysis of the European Commission "EU Cereal Farms Economics – FADN Report 2008". These data allow the reduction of the indicated margin (excluding direct payments) by the gross margin declines determined previously. These reduced gross margins have a direct impact on profits after deducting the fixed costs.

Reductions of gross margins affect farm net incomes of crop farms differently depending on the amount of fixed costs and stated farm net incomes. Yield reductions over 15% owing to a ban on azoles application in wheat producing farms would lead to serious declines in farm net income of between 20 and 70%. Germany with a low farm net income per enterprise (18.200 Euro) and a high fixed costs burden is particularly affected (Fig. 3.7 and Table 3.8).

Figure 3.7: Change of Farm Net Income (%) due to a ban of azoles (basis FADN 2006)



Sources: EU Cereals Farms Economics – FADN Report 2008, Update 17.06.2009
Own results

Table 3.8: Change of Farm Net Income (Euro) due to a ban of azoles (basis FADN 2006)

state	yield 100%	yield -5%	yield -10%	yield -15%	yield -20%	yield -25%
	Euro/Farm	Euro/Farm	Euro/Farm	Euro/Farm	Euro/Farm	Euro/Farm
UK	35.300	45.991	42.174	37.975	33.776	29.383
France	23.200	26.073	24.824	23.512	22.137	20.701
Germany	18.200	26.744	23.580	20.098	16.620	12.979
Poland	9.300	9.653	9.124	8.594	8.020	7.446

Sources: EU Cereals Farms Economics – FADN Report 2008, Update 17.06.2009
Own results

Conclusions of the farm business analysis

A restriction or a possible ban on azoles results in much less effective resistance management when combating fungal diseases in grain which leads to losses of profits up to over 60% due to high yield fluctuations. Varying climatic conditions during the growing season require a curative fungicide to combat these diseases efficiently. Solely protective treatments result in increased and more costly fungicide applications. Crop farms which are normally burdened with high fixed costs would have difficulty to absorb these profit fluctuations. Decoupled direct payments to farmers help to stabilize profits in case of increased yield fluctuations. If those payments were limited in future due to reforms in the framework of the European agricultural policy beyond 2013, a simultaneous restriction on fungicide management would cause clear destabilization of crop farm incomes.

4. Results of the sectoral analysis

So far the effects of a stricter regulation of azoles on farm businesses have been calculated. In this section the analysis is broadened to a sectoral level, taking into account the supply and the demand side, their interaction on national and international markets with respect to price formation, as well as the net trade and welfare effects of different scenarios. For this purpose the Agricultural Simulation Model “AGRISIM” is used, which has been developed at the University of Giessen. AGRISIM is a partial-equilibrium, multi-commodity-multi-region model. It is comparative static in nature, deterministic and has non-linear isoelastic supply and demand functions. Trade is modelled as net trade. Policy interventions considered include changes in nominal protection rates, price transmission coefficients, minimum producer prices, production quotas and various types of subsidies. Through shift coefficients in demand and supply functions additional exogenous variables can be taken into account and their impact can be simulated, such as population and income growth, technical progress or as in this case, yield losses due to different regulation levels for azoles. The current version of the model includes eleven commodities and fourteen regions/countries (see Table 4.1). The database was recently updated to the year 2006.

Table 4.1: List of commodities and regions

Commodities	Regions
Wheat Coarse Grain Rice Maize Oilseeds Soybeans Sugar Milk Beef Pork Poultry	Argentina Brazil Canada China EU-27 India Japan Mexico Russia South Africa Ukraine United States Rest of Europe Rest of the World

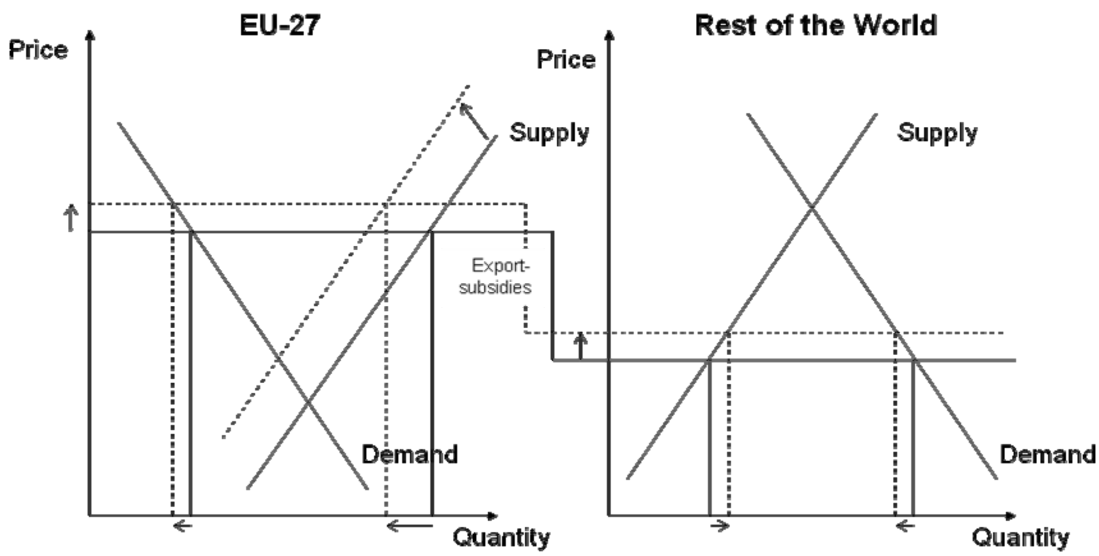
Data Sources from FAO, OECD, USDA, SWOPSIM/ERS/USDA for 2006

The principal functioning of the model and the sectoral effects of a policy-driven yield loss can be explained by the following simplified graphical illustrations (see Figure 4.1). The world market for a given commodity consists of two regions: The EU-27 and the rest of the world. The Common Agricultural Policy (CAP) leads to a price gap due to export subsidies and/or import taxes with higher prices in the EU-27 and lower prices on world markets. The world market is in equilibrium insofar as the net-export (net-import) of the EU-27 is equal to the net-import (net-export) of the rest of the world. This is the reference or benchmark situation. Yield losses can now be introduced into the graph by a shift of the EU-supply function to the left. Without changing the price gap (or in other words: with a given CAP) the following effects occur:

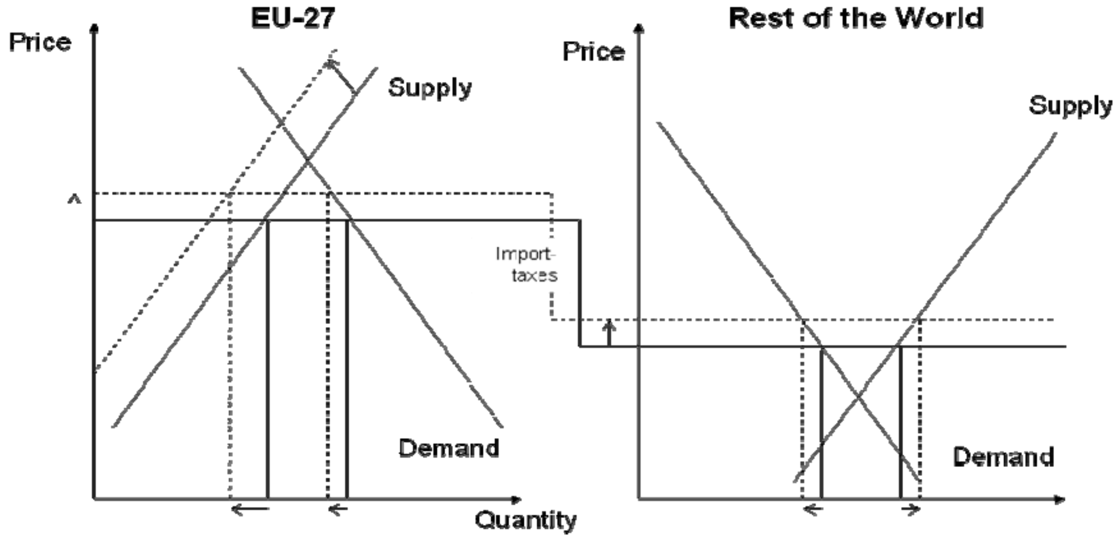
- A decline of EU production which is partly offset by a slight price increase;
- a decline of EU consumption;
- higher domestic and world market prices;
- an increase of production and a decrease of consumption in the rest of the world
- and finally depending on the trade structure of both regions a decline of EU net-exports and an increase of EU net-imports.

Figure 4.1: The Multi-Commodity-Multi-Region Simulation Model AGRISIM - A simplified graphical Illustration of the effects of yield losses in the EU-27

(a) EU-27 as exporter



(b) EU-27 as importer



More detailed and numerical results for different commodities and regions can be derived by using AGRISIM. Assuming different levels of yield losses up to 25% for wheat, maize, oilseeds and sugar as well as up to 6.25% for coarse grains and considering cross-price-effects on both sides, demand and supply, one gets the following results:

- **Production effects in the EU-27** (Figures 4.2 a – 4.6 a):
  Compared to the base year domestic wheat production is lowered by a maximum of 21%, oilseed production by 23%, sugar production by 25%, coarse grain production by 4.4% and maize production by 0.2%.
- **Trade effects in the EU-27** (Figures 4.2 b – 4.6 b):
  The net-trade position for wheat changes from an export status of 8.7 million tonnes to an import status of 14.4 million tonnes. The same result holds for the sugar (coarse grain) net-trade position changing from an export status of 4.9 (3.1) million tonnes to an import status of 0.5 (0.5) million tonnes. The net imports of oilseeds (maize) increase from 0.6 (2.2) million tonnes to a maximum of 4.8 (3.6) million tonnes.
- **Global production and trade shares** (Figure 4.7 – 4.14):
  The wheat production share of the EU-27 would decline from 20.9% to 16.9% and China and India are the beneficiaries. The USA and Canada especially benefit from the change in the EU wheat trade status. The oilseed production share of the EU-27 declines from 29.2% to 23.8% again with advantages for

China and India. The coarse grain and maize production shares are only marginally affected. The sugar production share of the EU-27 declines from 14.8% to 11.3% from which especially Brazil and Argentina benefit in production and trade status.

These findings are now presented in more detail in the remainder of this chapter.

EU-27 production and trade effects

The impact of reduced yields due to restrictions on azole-based fungicides on production and net trade of the EU-27 is shown in Figures 4.2 through 4.6 for the five commodities mainly affected namely wheat, oilseeds, sugar, coarse grains and maize. Note that the production effect is not identical with the initial assumed reduction in yields because, in the final market equilibrium, higher prices help to offset some of the production reduction caused by the assumed yield declines. For example, wheat production is projected to fall by 12.3% assuming yields are reduced by 15% (Figure 4.2).

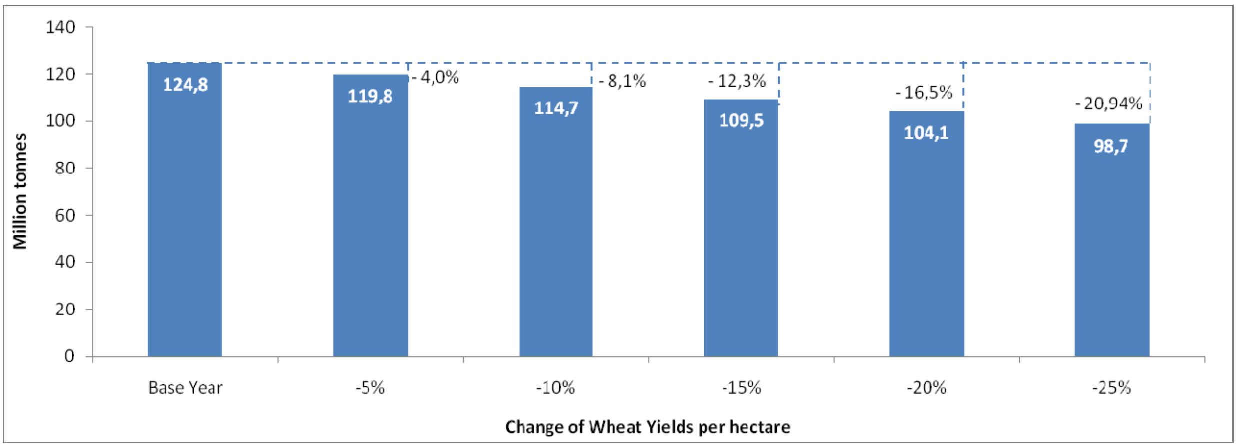
The one exception to this is the case of sugar, where yield reductions are assumed to be translated into a one-for-one reduction in production. In the case of sugar, the production decline is exactly the same as the yield decline because the production quota is modelled in AGRISIM.

In the case of maize, there is also virtually no change in production. Maize production would not be directly affected by a restriction on azole-based fungicides as these are not used in its cultivation. The yield reduction scenarios shown for maize in Figure 4.6 refer to the impact of yield reductions in the wheat-rape-sugar rotation and not to maize itself.

The net trade effects are all in the same direction as the production effects. In the case of wheat, for example, the net surplus observed in the base year would steadily shrink and turn into a net deficit, the greater the impact of restrictions on wheat yields. The same situation would be observed for sugar and coarse grains. In the case of oilseeds, the deficit observed in the base year would become even larger, as would also be the case for maize.

Figure 4.2: Effects of a ban of azoles in the EU-27

a) On EU-Wheat Production



b) On EU-Wheat Net-Trade (Export minus Import)

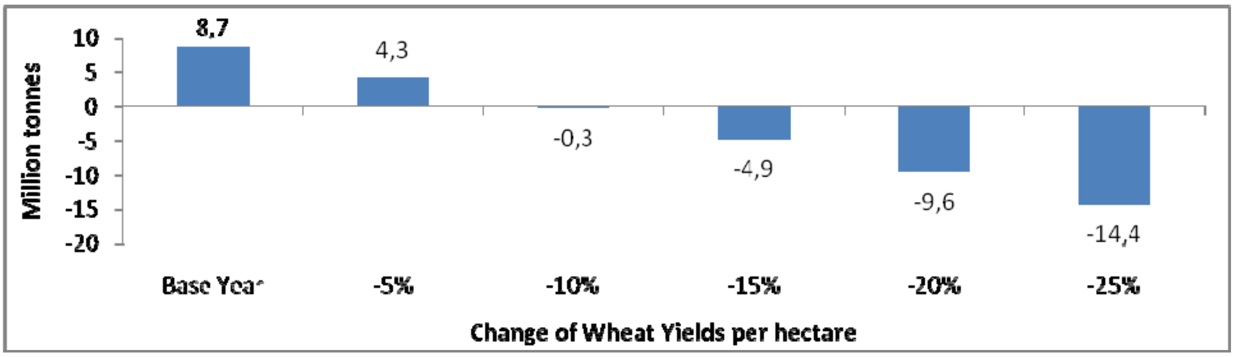
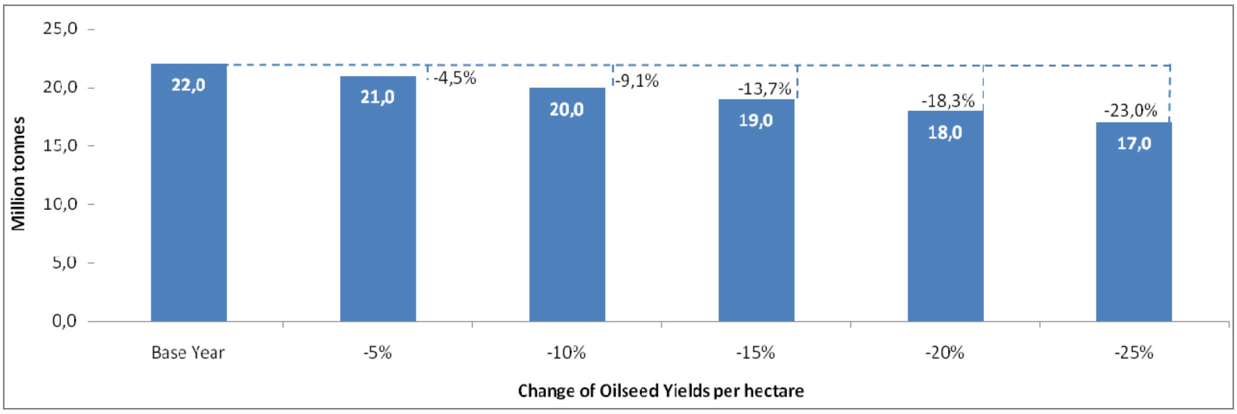


Figure 4.3: Effects of a ban of azoles in the EU-27

a) On EU-Oilseed Production



b) On EU-Oilseed Net-Trade (Export minus Import)

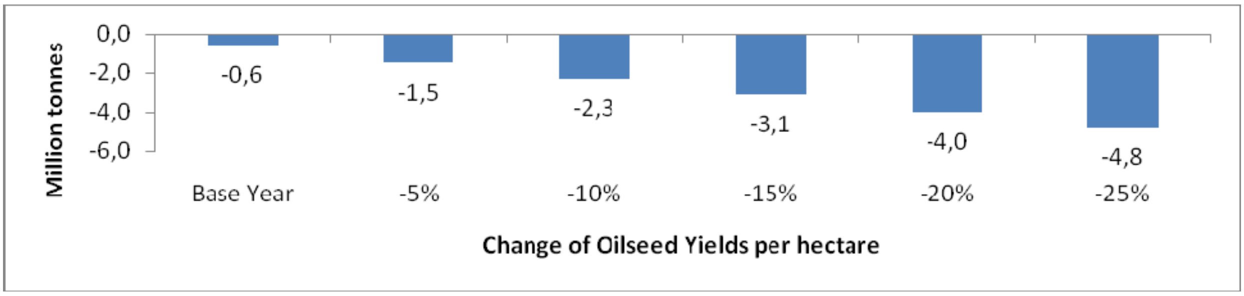
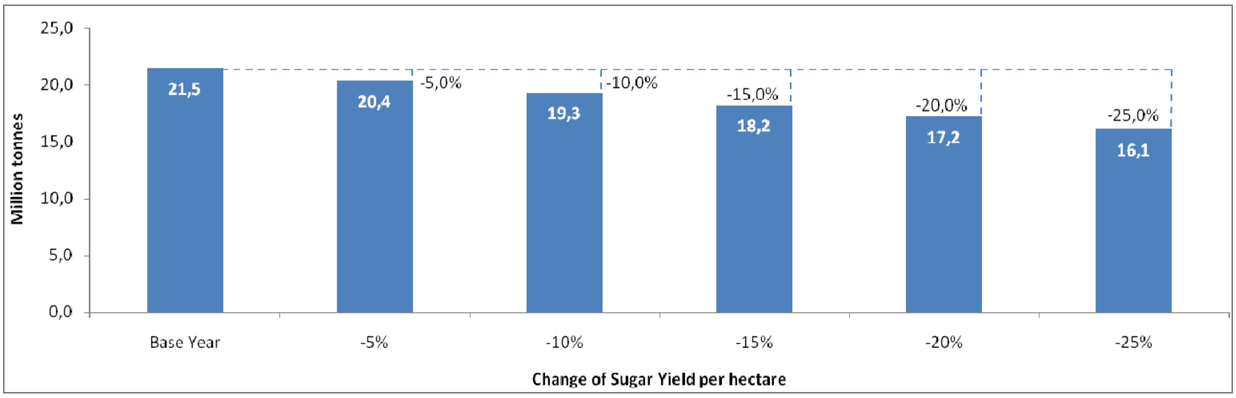


Figure 4.4: Effects of a ban of azoles in the EU-27

a) On EU-Sugar Production



b) On EU-Sugar Net-Trade (Export minus Import)

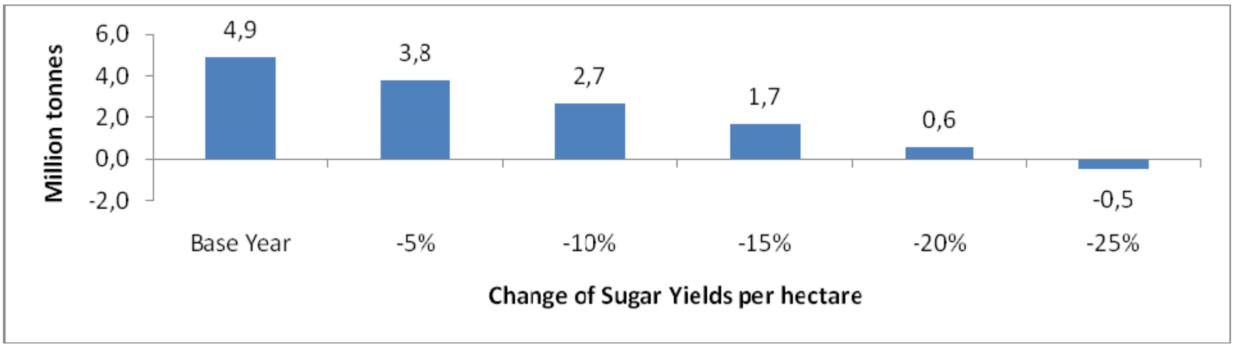
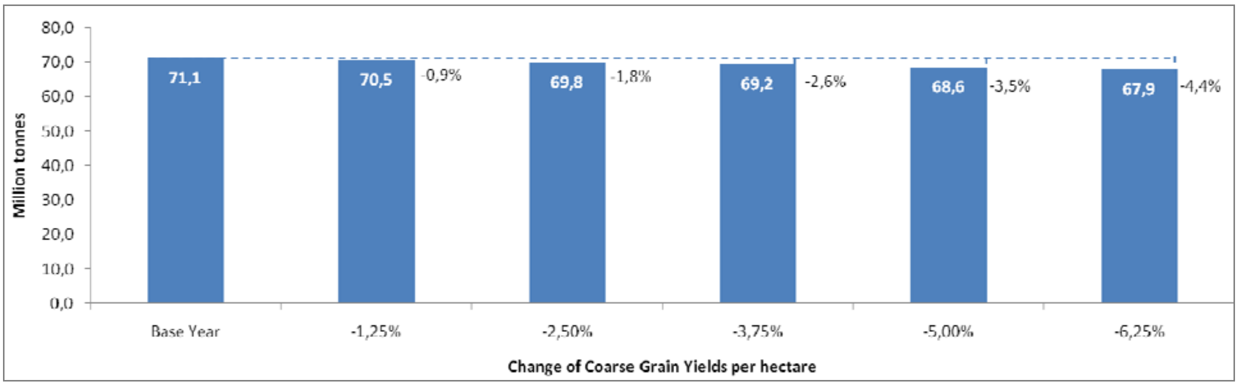


Figure 4.5: Effects of a ban of azoles in the EU-27

a) On EU-Coarse Grain Production



b) On EU-Coarse Grain Net-Trade (Export minus Import)

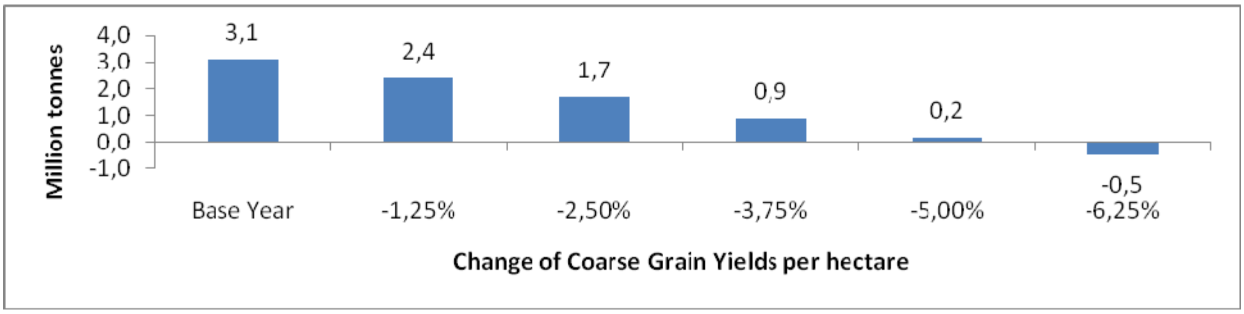
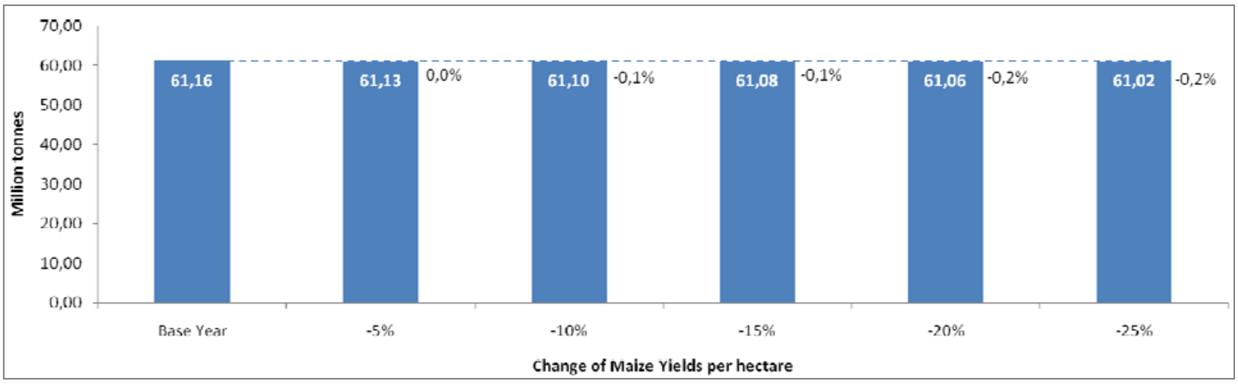
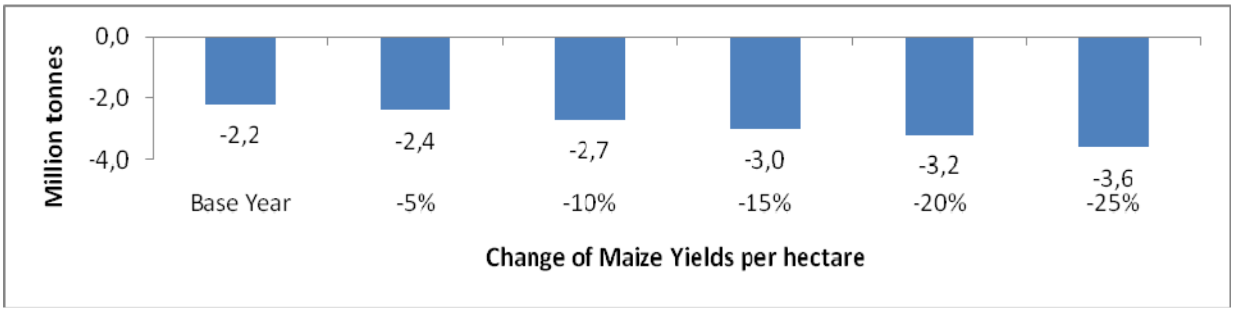


Figure 4.6: Effects of a ban of azoles in the EU-27

a) On EU-Maize Production



b) On EU-Maize Net-Trade (Export minus Import)



Changes in EU-27 shares in global production

Given that the EU-27 either shifts from a net export to a net import position for wheat, sugar and coarse grains, and increases its net import position in the case of oilseeds and maize, it is interesting to examine which are the other countries which would see an increase in production and net exports due to these reductions in EU self-sufficiency rates. In the case of wheat, the big winners turn out to be China and India, though production would also increase in the US and Canada. The effects on Russia and Ukraine turn out to be rather limited. China would increase its net exports of wheat, while India would reduce its dependence on imports, given the world market price increases assumed.

In the case of oilseeds, China and India are also shown to increase their shares of global production. Canada, Russia and Ukraine are among the beneficiaries in terms of net exports.

Production shares for coarse grains do not change significantly given the relatively small negative shock to EU-27 production. However, there would be changes to world trade flows, with US and Canada gaining in terms of net exports. Sugar production would shift towards Argentina and Brazil, with Brazil in particular likely to take advantage of a greater EU deficit by stepping up its net exports.

Figure 4.7: Shares of Wheat Production for Selected Countries/Regions

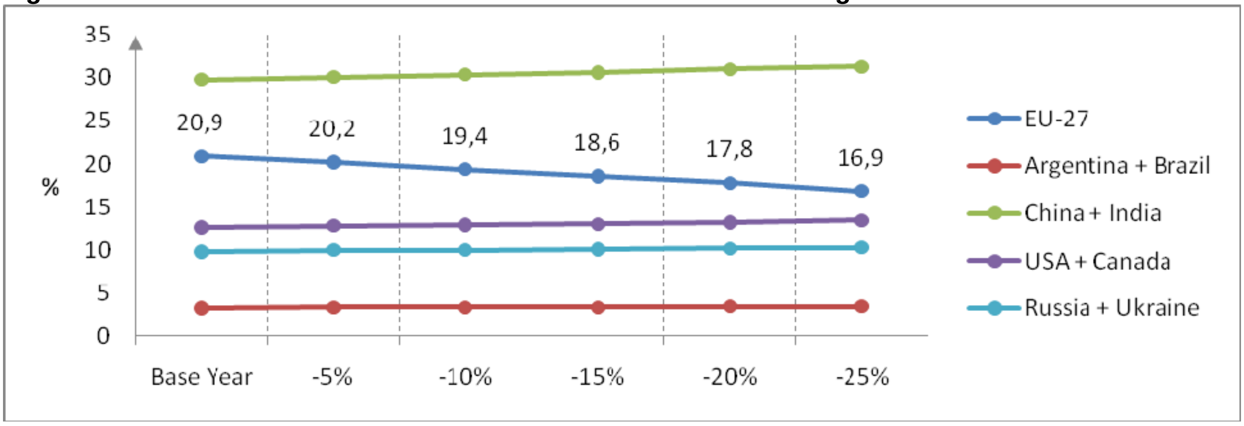


Figure 4.8: Net-Trade of Wheat for Selected Countries/Regions

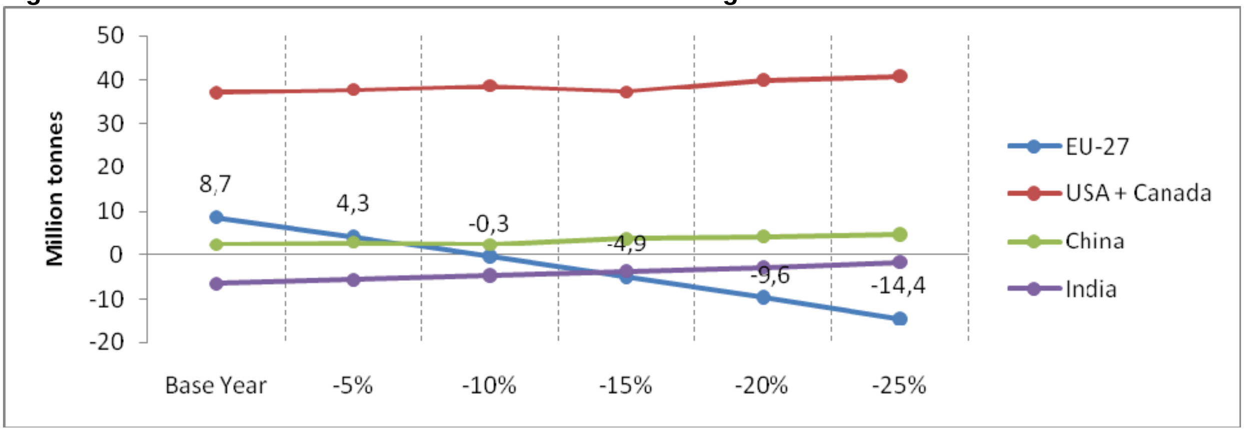


Figure 4.9: Shares of Wheat Production for Selected Countries/Regions

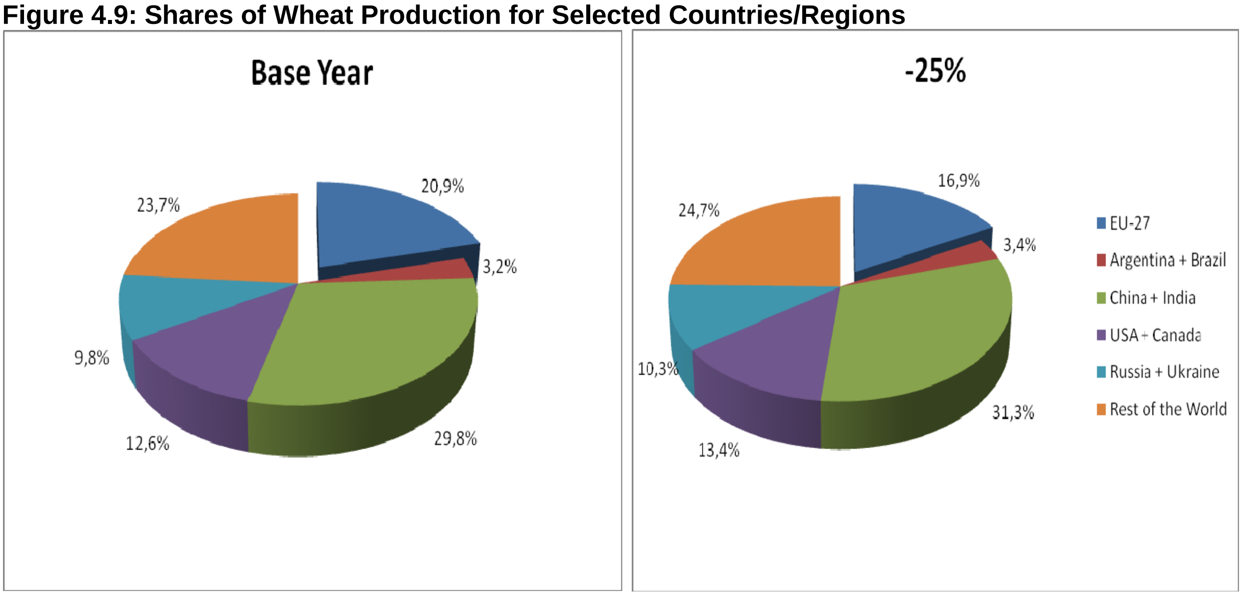


Figure 4.10: Shares of Oilseed Production for Selected Countries/Regions

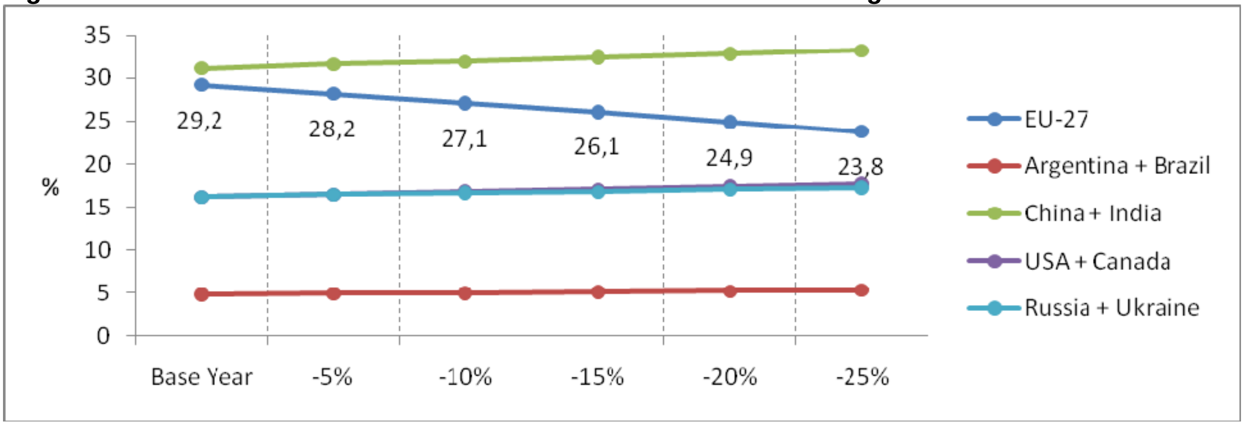


Figure 4.11: Net-Trade of Oilseed for Selected Countries

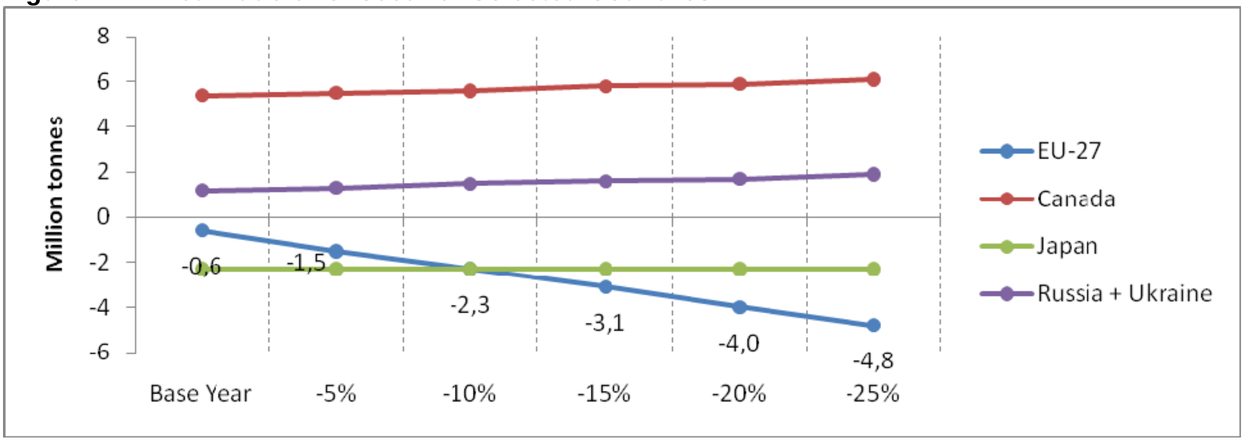


Figure 4.12: Shares of Coarse Grain Production for Selected Countries/Regions

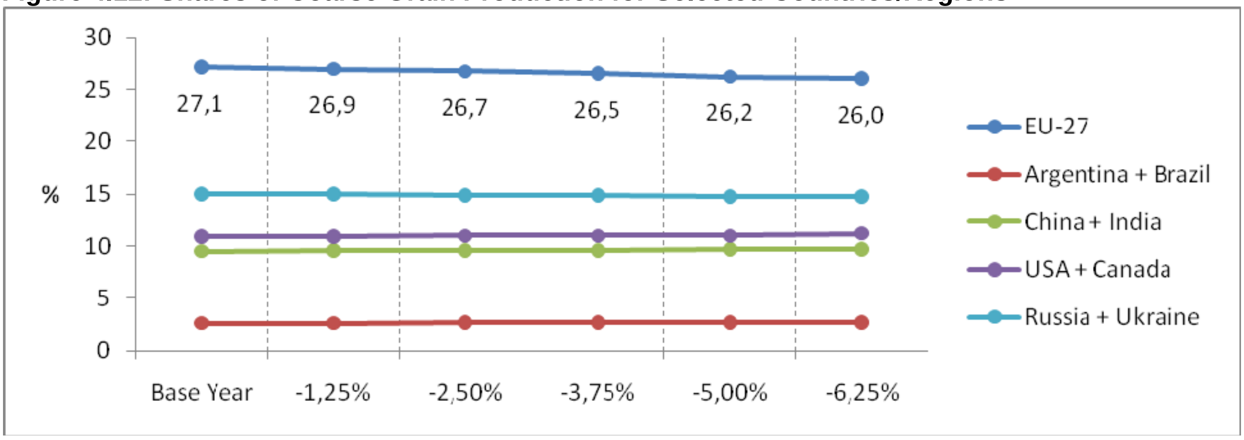


Figure 4.13: Net-Trade of Coarse Grain Selected Countries

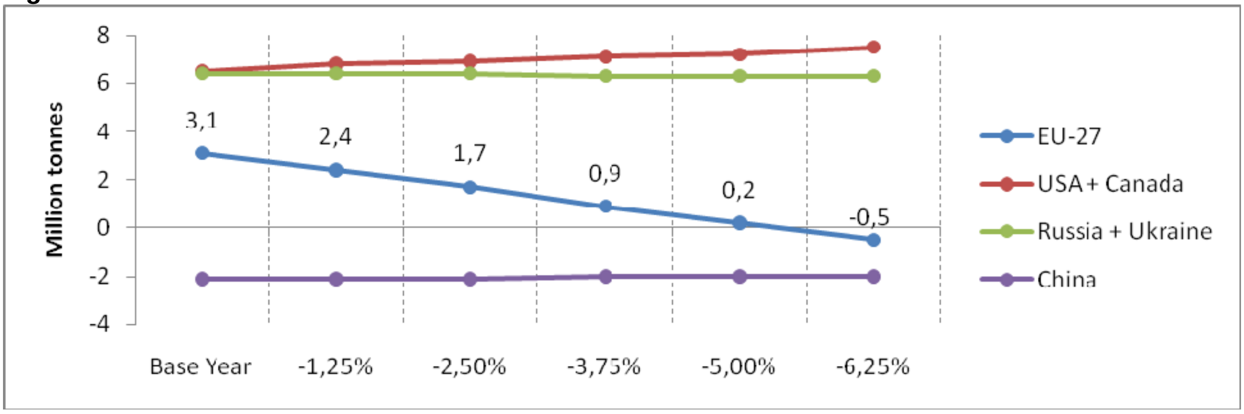


Figure 4.14: Shares of Sugar Production for Selected Countries/Regions

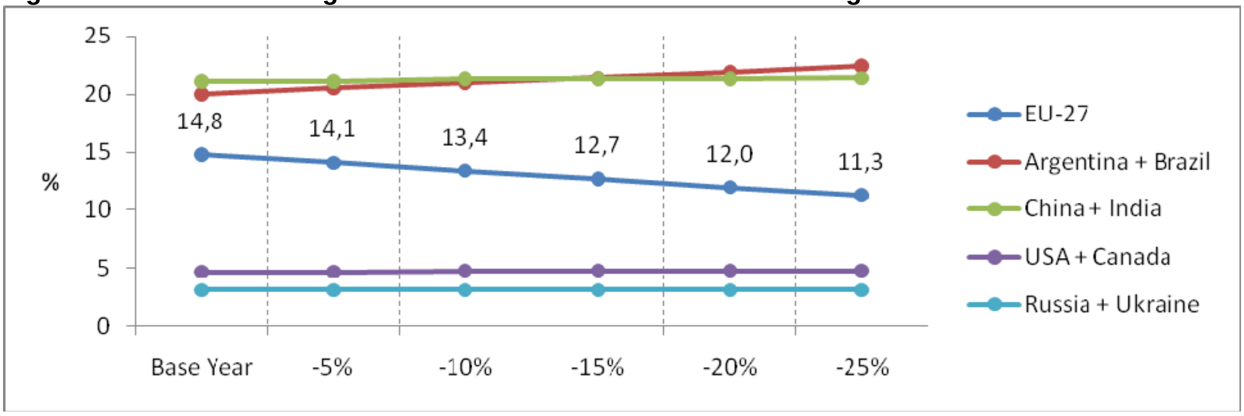
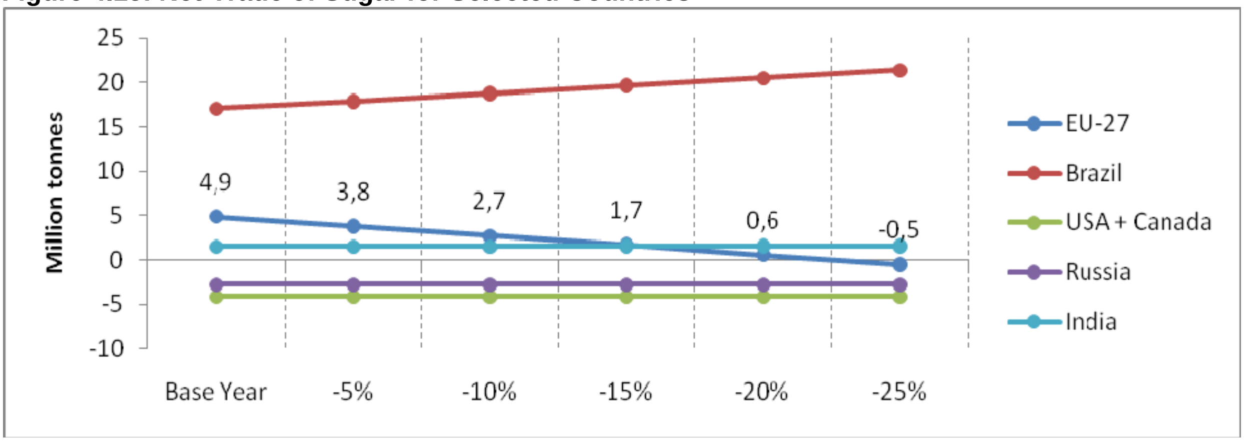


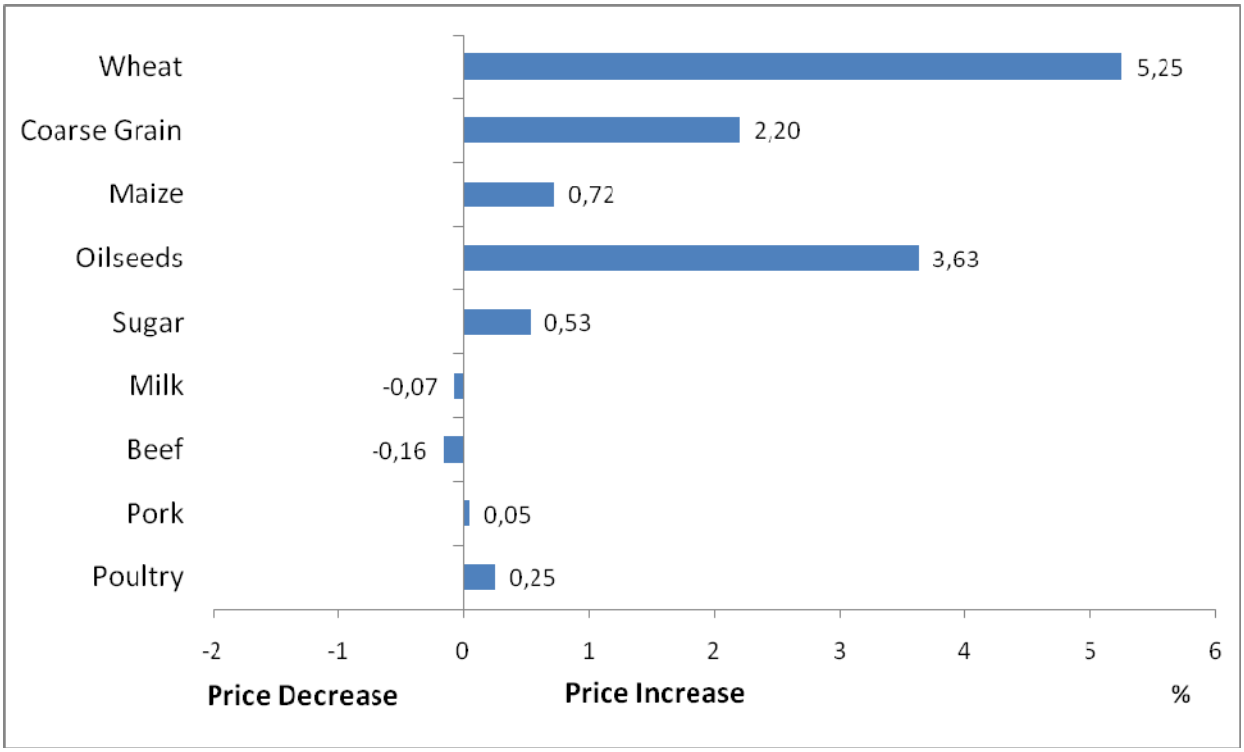
Figure 4.15: Net-Trade of Sugar for Selected Countries



EU-27 price effects

The largest impact on EU farmgate prices would be experienced by wheat growers (prices would increase by 5.25%) and oilseed farmers (up 3.63%). Pig and poultry prices would also increase partly in response to higher input costs. However, prices for milk and beef would decline a little as resources previously employed in arable farming shift into the production of these commodities.

Figure 4.16: Effects of a ban of azoles in the EU-27 on EU Farm Gate Prices of Selected Commodities*



*** % change due to a 15% (3,75% for coarse grain) yield reduction**

Welfare effects for EU-27 and other countries

The impact of different assumed yield reductions on economic welfare in the EU-27 is shown in Figure 4.17. The economic welfare of producers, consumers and taxpayers is separately distinguished. Despite higher domestic prices, EU producers would be negatively affected by the yield reductions consequent on a restriction on the use of azole-based fungicides. However, these higher prices would also adversely affect the welfare of consumers. While taxpayers would benefit from the reduction in export subsidies/increase in tariff revenue on imports, the combined effect on consumers and taxpayers (shown in red) would be unambiguously negative. In total, in the most extreme scenario, the overall EU-27 welfare loss could amount to USD 5.6 billion.

The welfare impacts on third countries are shown in Figure 4.18, for an intermediate scenario where yields are assumed to fall by 15% (3.75% for coarse grains). Globally, of course, the world is worse off by the impact of restricting a useful technology. For the countries shown in the figure, higher world market prices lead to a positive net welfare gain – the gains to India and China reflect their importance as global producers of wheat. However, for other groups of countries not shown in the figure, particularly net importing countries in the developing world, the net welfare effects are shown to be negative.

Figure 4.17: Total Annual Welfare losses due to a ban of azoles in the EU-27

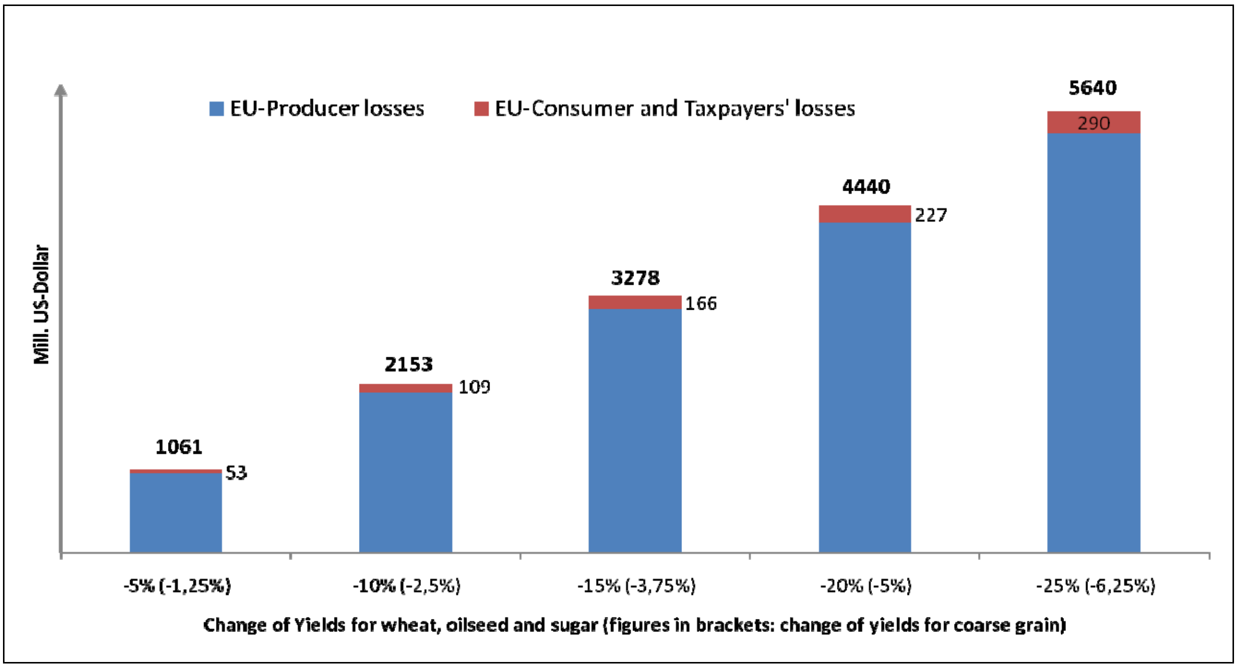
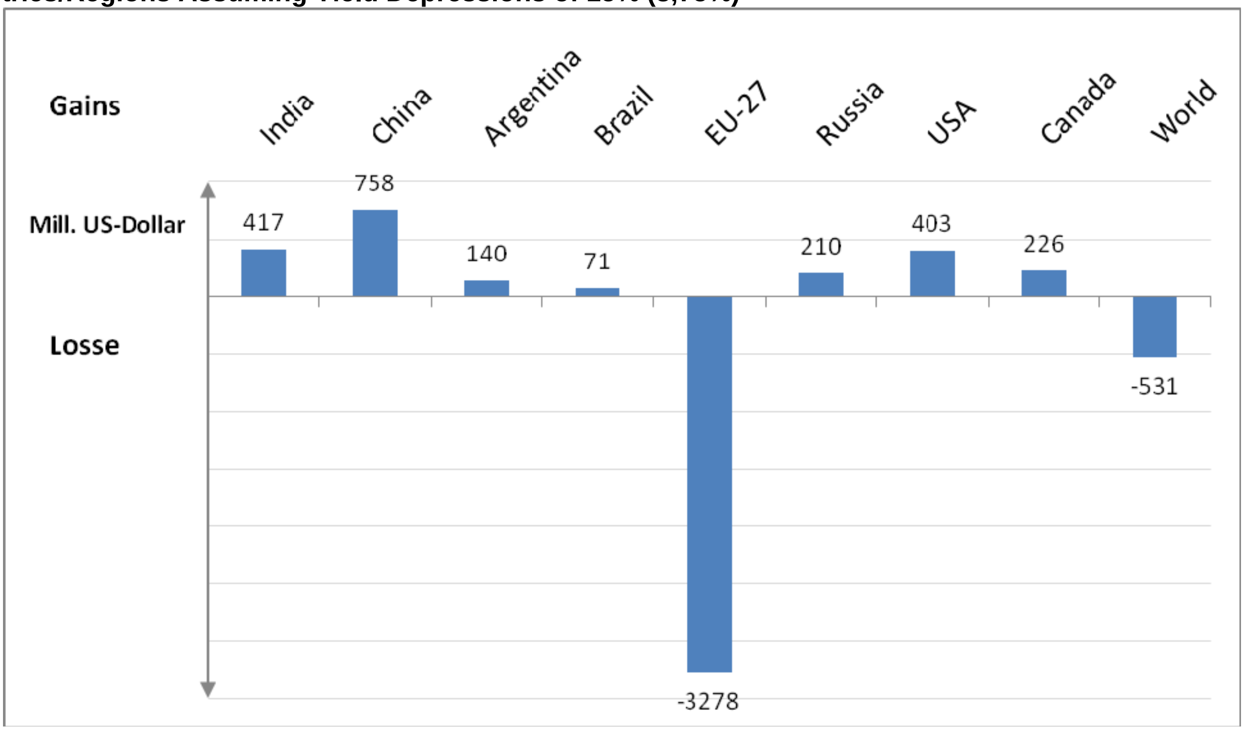


Figure 4.18: Total Annual Welfare Effects of a ban of azoles in the EU-27 for selected Countries/Regions Assuming Yield Depressions of 15% (3,75%)



5. Conclusions

Key messages from the expert interviews

The target group for the expert interviews were leading farmers (n = 49) with a minimum winter wheat cultivation area of 50 hectares and technical experts (n = 36) in Germany, France, UK and Poland, giving a sample size of 85 interviews.

- The (future) importance of azoles is assessed very highly and favorably by all countries, especially by French, English and German technical experts and farmers.
- Key statements: Azoles are not replaceable, have highest impact on plant health and yields, are essential to keep resistances down, play a critical role for eradication activity especially on septoria and fusarium, and are a crucial chemical because of its all-round capabilities.
- Farmers and technical experts underlined the difficulty to substitute for the azoles (ratings between 8 and 10, scale 0-10, 10 = very difficult to substitute). The lower rating for azoles in Poland could be due to a higher efficacy of strobilurins and morpholines in that country to date.
- Restriction of azoles would have a dramatic impact in all four countries in various dimensions:
  Proper resistance management would become almost impossible (increased resistances!).
  Disease control options would be significantly more limited, leading to inability to eradicate core diseases (septoria and fusarium), reduced efficacy, and higher disease levels (+ 50% UK).
  Yields would decrease significantly (average = Germany 17%, UK 10 -15%, France 20%).
- With respect to benchmarking different active ingredients (AIs) of the azoles:
  All active ingredients except for prothioconazole are judged much worse than epoxiconazole, especially by technical experts in all countries.
- When the qualitative statements are analyzed, epoxiconazole is better evaluated compared to prothioconazole.

Key messages from the farm business analysis

Impacts on costs and benefits of cereal farms in case of a ban of azoles and reduced fungicide application were calculated based on gross margin analysis. A standardized crop rotation with 33% winter wheat, 33% winter barley, 29% rape and 5% sugar beet is assumed for the calculation.

- Gross margins will decrease significantly in case of a ban of azoles (scenario 1: assumption yield decrease 25%):

  UK - 9%
  Germany - 11%
  France - 11%
  Poland - 21%

- Farm net incomes will also decrease significantly in case of a ban of azoles and may threaten the existence of cash crop farms:

  France - 11%
  UK - 17%
  Poland - 20%
  Germany - 29%

- A restriction or a possible ban on azoles results in much less effective resistance management when combating fungal diseases in grain which leads to losses of profits up to over 60% due to high yield fluctuations.

- Varying climatic conditions during the growing season require a curative fungicide to combat fungal diseases efficiently. Solely protective treatments result in increased and more costly fungicide applications. Crop farms which are normally burdened with high fixed costs can hardly absorb these profit fluctuations nor react to them.

- Decoupled direct payments to farmers help to stabilize profits in case of increased yield fluctuations. If those payments were limited in future due to reforms in the framework of the European agricultural policy beyond 2013, a simultaneous restriction on fungicide management would cause clear destabilization of crop farm incomes.

Key messages from the sectoral analysis

- An EU-ban of azoles reduces EU production of wheat, oilseeds and sugar by 18% to 25% in the worst case (scenario 1) while all other producers on world markets increase both their production volumes and shares.

- The EU net trade position of the three commodities is heavily affected. The EU changes its trade status from a net-exporter to a net-importer for wheat and sugar and significantly increases its oilseed imports.

- The total annual EU welfare loss in case of a ban of azoles comes to 5.6 billion US dollars (scenario 1) and is mainly borne by producers. But also consumers are negatively affected, because prices of most crops and of white meat products increase and EU taxpayers and consumers combined bear an additional burden of 173 million US dollars for an increasing budget.

- Net-importing countries and consumers in the third world are negatively affected by world market price increases of 6% to 9% for oilseed and wheat and by total welfare losses.

- More land is necessary to compensate for the yield losses and in addition to meet the food requirements of a growing population.

Key messages for policy-makers

- Risk management requires a socio-economic appraisal of the benefits from pursuing a course of action (in this case, introducing greater restrictions on or possibly banning the use of azole-based fungicides in crop protection) in comparison with the costs. This study does not attempt to measure any potential benefits to human health or the environment (although we note the views of qualified expert opinion that "no meaningful benefits to public health protection from any criteria, beyond those delivered by the existing risk assessment arrangements, have been demonstrated".[9]) However, the study does underline the potentially severe effects of further restrictions on the use of azoles on the economic viability of important elements of European agriculture.

- At a technical level, reliance on a narrow range of fungicidal products increases the likelihood of disease resistance. The analysis shows the importance of maintaining as broad a spectrum of plant protection products as possible to avoid the growth of disease resistance. The azoles, and particularly epoxiconazole, are important because of their curative as well as protective properties. Maintaining access for farmers to these active ingredients will reduce the pressure to increase more than proportionately usage of other, less effective, substitutes.

- At the farm level, the prohibition of azole-based fungicides will reduce significantly the profitability of a core component of EU agriculture, particularly in countries such as Germany where crop farmers have high fixed production costs. Because the severity of fungal disease attacks varies from year to year depending on weather conditions and other factors, farm income will also be less stable if azole-based fungicides are no longer available.

- For European agriculture, in the most severe scenario of a ban on azole-based fungicides, reductions of 18% to 25% in the production of wheat, oilseeds and sugar can be foreseen. These production decreases will lead to lower exports and greater imports and will put upward pressure on already-high global prices for these products, creating further difficulty for net-importing countries already struggling to finance high food import bills.

- It is important to take these negative effects on European farming and food into account in arriving at an informed judgment on the appropriate response to managing pesticide risk. Policy-makers must assess if indeed there are public health or environmental benefits which might justify such a damaging outcome for European agriculture.

[9] See UK Pesticides Safety Directorate *op. cit.*

Appendix

Figures

Tables

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