

Institut für Agribusiness

Agro-Economic Analysis of the use of Glyphosate in Germany

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1 Introduction

Background and goals of the study

On a Regular basis the compulsory re-accreditation of active substances in plant protection agents is on the agenda. This is also the case for the active substance Glyphosate. This is a broad spectrum, non-selective herbicide, widely used for the post-emergence control of annual and perennial weeds in a variety of agricultural and non-crop applications and plays a pivotal role in combating weeds, particularly in environmentally friendly conservation tillage. In any re-accreditation related to herbicides the importance of plant resistances in the field of weed control has to be taken into consideration. Therefore, to slow down the rate of spread of weed resistances the maintenance of a broad spectrum of active substances is of paramount importance.

The present study on the active substance Glyphosate, is firstly devoted to the economic aspects. For this purpose, it is worked out which positive economic effects the use of Glyphosate has in crop production and which consequences would result from a ban on Glyphosate, respectively. To achieve this, the changes in production quantities, the price of agricultural produce, the profit margins and the welfare economic aspects are described. The active substance Glyphosate in connection to its different formulations is repeatedly subject to critique, for leaving behind degradation products in soil and in water with harmful effects for plants and ultimately also for the human being. Therefore, concluding the current state of knowledge on the environmental effects of Glyphosate should be reviewed.

Methodologies used

The study considers the effects of a complete discontinuation of Glyphosate use without the existence of an as effective and equitably alternative product in crop production on two corresponding levels (Figure 1.1):

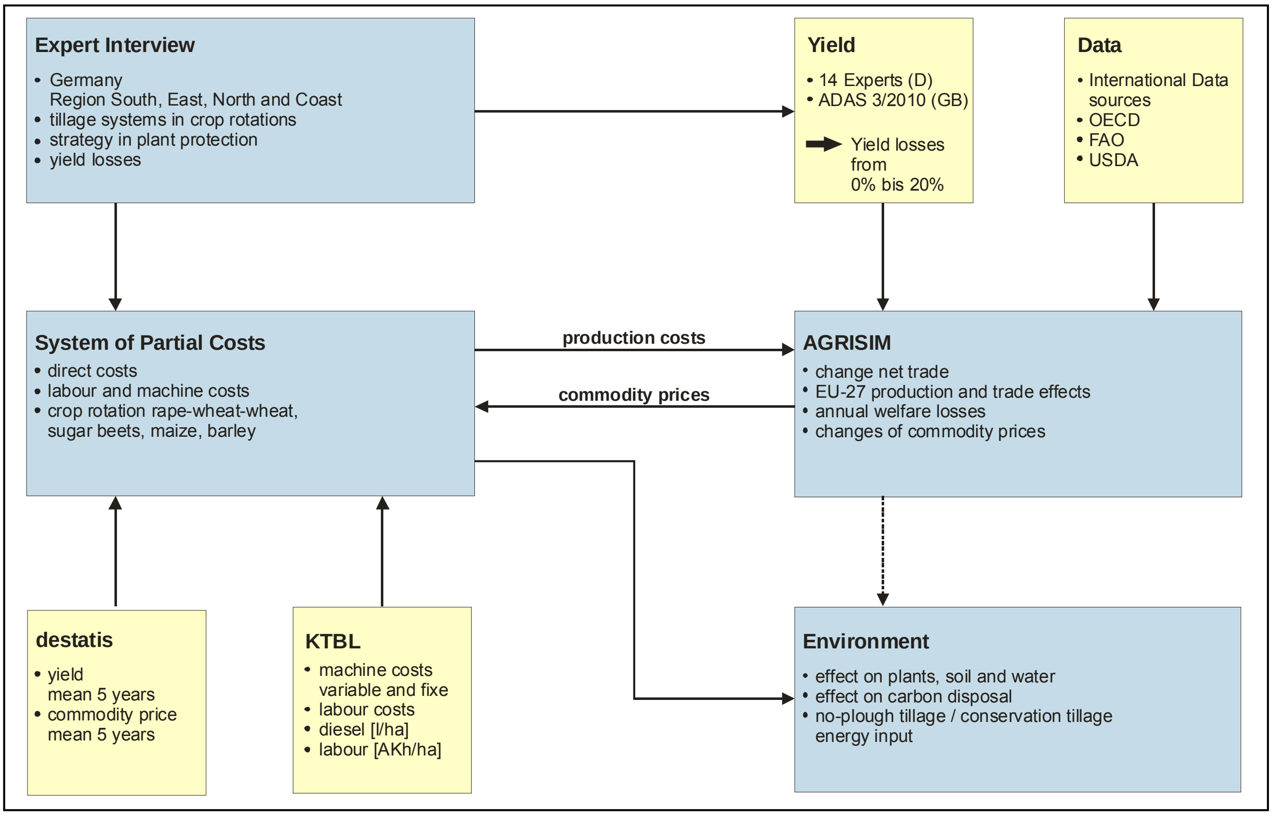
a) In a direct costing framework, the impacts on the cost and performance level per hectare for Germany are considered.

b) In a sectoral analysis with the AGRISIM model, the impact on production, trade and welfare is calculated.

To initially create a data basis for direct costing, in 14 expert interviews regionally differentiated information for Germany was collected, concerning:

- Strategies of application and extent of use of Glyphosate,
- Different strategies in herbicide use and in tillage depending on the possibility to apply Glyphosate or not,
- Reduced tillage systems,
- Possible yield depressions in case of a non-application of Glyphosate.

Figure 1.1: Methodology and Data Origin



Source: own representation

The results of the expert interviews form the basis for the direct costing framework. Likewise yield and prices from the Federal Statistical Office and Machinery costs on the basis of KTBL-Data are included in the performances and costs. Target costing moreover considers the feedback prices for wheat, barley, maize, rapeseed and sugarbeet from the sectoral model.

The cost increase in the production systems calculated using the direct costing framework, as well as a possible yield depression on the european region in the range between 0% and 20%, serve as a basis for the calculation of the sectoral changes in the AGRISIM model. As a result, changes in net trade, the commodity prices and the welfare for the EU-27 and other selected countries are presented.

In a literature analysis and under consultation of the results from the direct costing framework and the sectoral model AGRISIM, the possible environmental impacts of Glyphosate on soil and land use as well as plants and water are evaluated. Furthermore, the importance of Glyphosate for reduced tillage is considered under the aspect of energy and labor input (expenses).

2 Results of the Expert Interviews

Method

The expert interviews have been conducted with overall 14 plant protection consultants of the public advisory offices in Germany. The interviews took place in April 2011. The consultants originated from agriculturally differently characterized regions and thus have therefore given statements on application and processing techniques and implications typical for their region.

Thus, the objectives of the expert interviews were:

- To get an overview on the application and use of Glyphosate in crop farming in Germany.
- To determine the importance of Glyphosate for the resistance-management in crop farming.
- To assess the possible restrictions of Glyphosate economically and based on that conduct a welfare-economic assessment for Germany and Europe.

Therefore, the expert interviews have been split into three main parts. Following thematic blocks were discussed with the experts:

- Regional frequency of application and application rates of Glyphosate for pre-harvest, stubble, pre-sowing and pre-emergence treatment for the agriculturally most important crops.
- Reasons behind the individual applications.
- Production-technical related changes and yield depressions in case of a non-avaliablity of Glyphosate-containing plant protection agents in agriculture.
- Relevance of the active substance Glyphosate for long term resistance management.

Due to the regionally very divergent answers, Germany for the purpose of further analysis and portrayal of results has been divided into four regions:

1. Southern Germany

   includes the federal states of Hessen, Rheinland-Pfalz, Saarland, Baden-Württemberg and Bayern. In these regions the use of the plough for tillage still plays an important role. Moreover, there are only relatively minor problems with herbicide resistance in this area.
2. East Germany

   Includes the new federal states of Germany. In this region in contrast to Southern Germany the conservation-tillage plays a pivotal role. Accordingly, Glyphosate is used frequently in crop rotation.
3. Northern Germany

   Includes the agriculturally intensively cultivated areas in the federal states of Niedersachsen and Nordrhein-Westfalen. Despite the utilization of the plough in this region, Glyphosate still plays an important role. Furthermore, the region is affected by herbicide related issues of resistance and high pressure from weeds.
4. Coastal areas

   Includes the marschland areas in the federal states of Niedersachsen and Schleswig-Holstein. In this region herbicide resistances to blackgrass and other persistent, leading weeds in grain cultivation can be frequently observed. Therefore, in many areas the application of a total herbicide becomes compulsory, partially despite the use of the plough.

Importance of Glyphosate in plant production

In the framework of crop farming Glyphosate is applied at four different points in time. Firstly it can be used for the pre-harvest of cereals-, rapeseed, and legume crops. By treating the crops to a maximum of seven days before the harvest, weeds can be killed off in the stock or the maturation of the stock is faster and more uniform. The weed density is reduced and grain moisture content decreases. This facilitates better planning of the harvest and lower drying costs. The application on the stubbles of winter wheat and winter rapeseed, or alternatively to prepare the cultivation area for the summer crops in spring, can be identified as the second application period. Through this treatment emerging volunteer cereals and weeds are eliminated. In this context reference is also made to eliminating the “green bridge“. Weeds and volunteer cereal plants can otherwise act as an intermediate host for various diseases. Moreover, Glyphosate can be applied at the time of pre-sowing or alternatively pre-emergence, which corresponds to the time up to five days post-sowing. In this way, especially freshly germinated blackgrass but other weeds also, can be dealt with efficiently. Mechanical tillage can also act as an alternative to a Glyphosate treatment. Mechanical treatment however, is linked to lower effectiveness-levels in treating weeds.

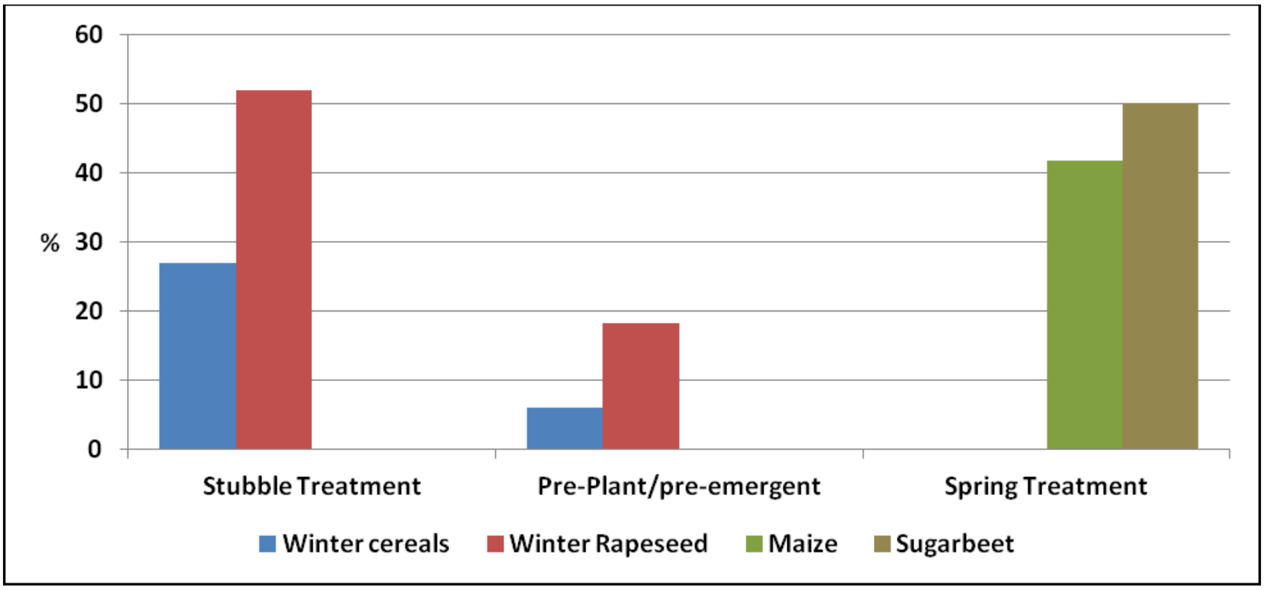
Table 2.1: Crop area of the main cultures in Germany in 2010 (Mill. ha) - arable land overall: 11.936 Mill. ha

	Winter-Cereals	Winter-Wheat	Winter-Barley	Winter-Rape	Maize	Sugar beets
area	5.601	3.263	1.303	1.469	2.310	0.367

Source: BMELV, 2011b

Germany in the year 2010 had 11.9 Mill. ha arable land (Tab. 2.1).Overall annually 30% of the arable land is treated with Glyphosate. These figures correspond to the sales figures, which obligatorily are reported to the Federal Office for Consumer Protection and Food Safety by the manufacturers and distributors (BVL, 2010). Figure 2.1 shows the different application priorities for the individual crops.

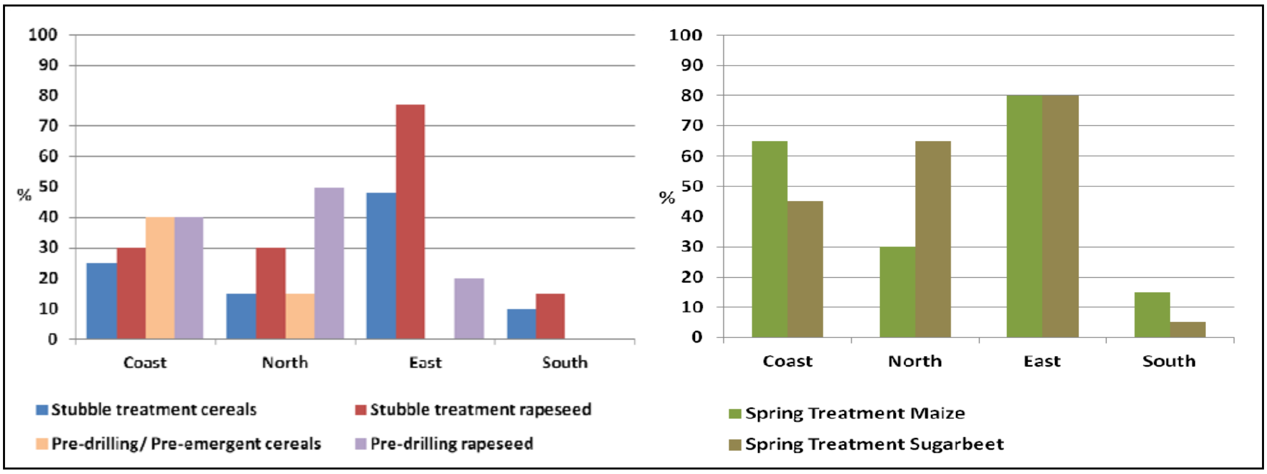
Figure 2.1: Share of the arable land treated with Glyphosate in Germany



Source: Results of Expert Interviews, 2011

The stubble treatment with Glyphosate after the cultivation of winter grain, is applied on 27% of the area. The emerging volunteer rapeseed after the harvest, is treated with the help of Glyphosate on 52% of the cultivated area. An application for pre-emergence or pre-sowing treatment only plays a subordinate role. 6.2% of the wheat-cultivated area, 5% of the winter-barley-cultivated area and 18.3% of the winter-rapeseed-cultivated area are treated. For maize cultivation 42% of the respective area are treated with Glyphosate beforehand. Whereas in the case of sugarbeet cultivation this share amounts to 53%. The pre-harvest treatment for a better maturation or weed control respectively, plays a subordinate role for the whole of Germany, therefore it is not listed here. However, pre-harvest treatment is of strong regional significance. In order to efficiently treat the standing weed in barley, in the coastal region around 65% of the winter barley area undergoes pre-harvest treatment with Glyphosate, owing to the fact that at this point in time plenty of receptive green mass is present. In the eastern region the pre-harvest treatment plays an important role to improve harvest management. In weather-wise average years, about 10% of the winter cereals and winter rapeseed crops are treated, in wet years this ratio can increase up to 20%. In the remaining regions, also in wet years or years with poor weather conditions in spring, as for example in 2011, less than 5% of arable land are treated.

Figure 2.2: Share of the arable land treated with Glyphosate in the different regions



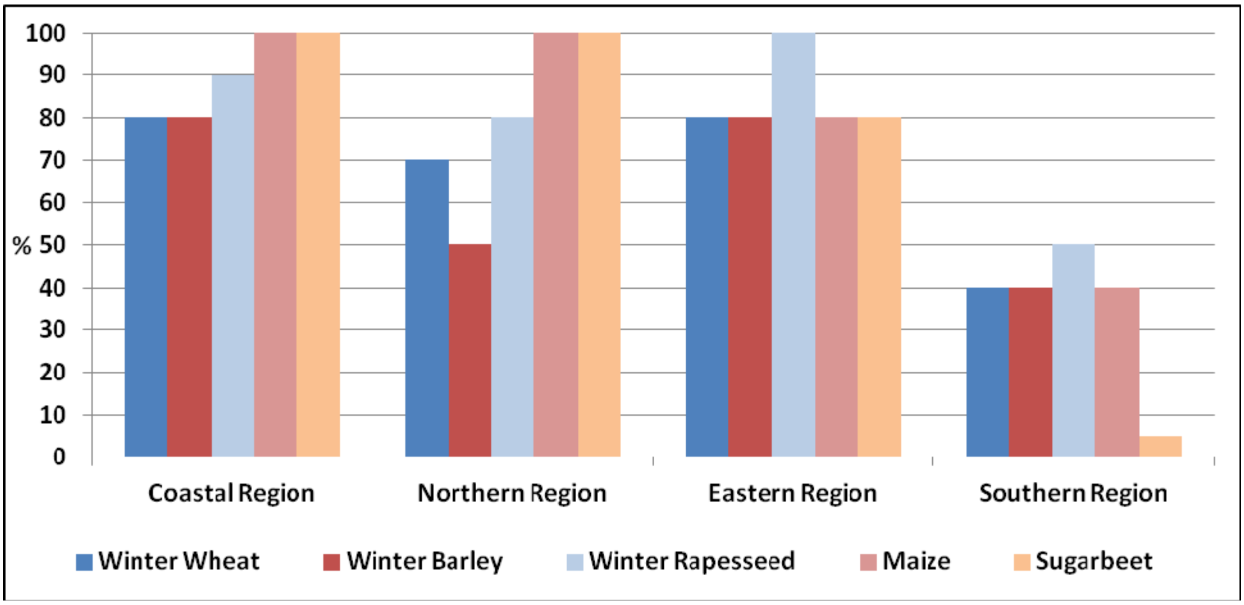
Source: Results of Expert Interviews, 2011

Figure 2.2 depicts the regional differences in Glyphosate application. In the coastal region all applications play an important role and cover on 25% to 65% of the arable land. In the Northern Region besides the treatment of rapeseed stubbles and rapeseed areas, especially sugarbeet is treated prior to sowing. In the Eastern Region the pre-sowing and pre-emergence treatments for winter cereals and winter rapeseed do not play an important role, whereas all other treatments with 48% to 80% are of pivotal importance. In the southern German region Glyphosate treatments hardly have any relevance. Pre-sowing and pre-emergence treatments in autumn do not take place at all. Stubble treatments and spring treatments with 5% to 15% are of minor importance.

Relevance of Glyphosate for no-plough tillage (mulch-sowing)

According to the agricultural census 2010 approximately 44% of the arable land in Germany is cultivated using conservation tillage (STATISTISCHES BUNDESAMT, 2011). According to a study conducted by the market research company Kleffmann Group in autumn 2010 already 53% of the winter rapeseed area and nearly half of the winter cereal area have been cultivated using no-plough tillage systems. In the year 2005 these figures amounted to only 35% for winter cereals and only 36% for winter rapeseed, respectively (AGE, 2011). This goes to show that conservation tillage is clearly on the rise. Therefore, in a further step the experts were asked to assess the relevance of Glyphosate for conservation tillage. Figure 2.3 shows the share of the no-plough tillage (mulch-sowing) areas treated with Glyphosate.

Figure 2.3: Share of the no-plough tillage (mulch-sowing) areas treated with Glyphosate



Source: Results of the Expert Interviews, 2011

Especially in the coastal and eastern regions the use of Glyphosate plays a very important role. In these regions for every crop more than 80% of the no-plough-tillage areas (mulch-sowing) are treated with Glyphosate. In the northern region almost 100% of the no-plough-tillage (mulch-sowing) areas for maize and sugarbeet are treated. Whereas, in the case of winter barley and winter wheat the treated areas with shares of 50% and 70% respectively, are slightly smaller. This surely is owing to the fact that particularly winter barley often is planted after root crops that largely facilitate a weed-free seeding-bed. In the south at most 50% of the no-plough tillage (mulch-sowing) area is treated, particularly depicting the rather low importance of Glyphosate in the region.

Agronomic changes in case of a ban on Glyphosate

In their conversations the experts have depicted the region-specific tillage and plant protection mechanisms as they are put into practice by the farmers who apply Glyphosate in crop rotation. The crop rotation with the crops winter rapeseed / winter wheat / winter wheat or winter barley formed the basis for the conversations. Furthermore, the production process related changes for the summer crops maize and sugarbeet were discussed. Subsequently, the changes resulting from a Glyphosate ban were discussed. Then based on the responses standardized tillage and plant protection strategies were derived for the individual regions.

The farms in both the **northern and southern regions** so far plough only once in crop rotation, namely the winter wheat after the winter wheat. The cultivation using conservation-tillage is realized by two stubble cultivations in combination with one Glyphosate treatment. Resulting from a Glyphosate ban an additonal stubble cultivation would become necessary for the mulch seeds (Table 2.2). Moreover, for winter wheat after winter rapeseed an additional soil herbicide would have to be applied to compensate the increased risk of resistance formation from the non-availability of the active substance Glyphosate. For the control of the increased pressure from grasses in winter rapeseed cultivation an additional leaf herbicide that would be spread in one additional drive-over, would have to be applied. On a mid-term basis, through these measures the yield depressions could possibly be prevented. Although the formation of resistances in case of a renouncement of an entire active substance group would be significantly accelerated. In some regions this would surely lead to yield depressions. The particular problems in this case are reasoned in the fact that up to a certain degree of resistance, namely approximately 30%, no problems can be detected in the crop stand. Hence, in a relatively short period of time certain areas would surely be affected.

Table 2.2: Production changes for the crop rotation in case of a ban on Glyphosate in the Northern and Southern Region

Rotation period	Tillage	Plant Protection	Yield
Rapeseed after Wheat	One additional stubble tilth	One additional leaf herbicide	No changes
Wheat after Rapeseed	One additional stubble tilth	One additional soil herbicide	No changes
Wheat after Wheat	No changes	No changes	No changes

Source: Results of Expert interviews, 2011

Table 2.3: Production changes for the crop rotation in case of a ban on Glyphosate in the Coastal Region

Rotation period	Tillage	Plant Protection	Yield
Rapeseed after Wheat	One additional stubble tilth	One additional leaf herbicide One additional drive over	-5%
Wheat after Rapeseed	One additional stubble tilth	One additional leaf herbicide Higher Application Rates in Spring	-5%
Wheat after Wheat	One additional stubble tilth	One additional leaf herbicide Higher Application Rates in Spring	-5%

Source: Results of Expert interviews, 2011

The herbicide resistances play an important role in the **coastal region**, especially the blackgrass on most arable areas is resistant to the most important active substances. Hence, despite the standardized use of the plough Glyphosate is strictly applied, either for the stubble treatment or for the pre-emergence treatment with the objective to decelerate the speed of the resistance spread. In the problematic areas, the application is necessarily required. The non-availability of the active substance would therefore lead to severe problems in these areas (Table 2.3). The experts expect medium-term yield depressions of 5%. Prior to sowing, the Glyphosate treatments would be replaced by an additional stubble cultivation or an additional seed-bed preparation to control the newly accumulated blackgrass. Furthermore, an additional herbicide treatment would be necessary as a supplement to the existing two treatments in order to introduce an active substance change to control permanently persistent grasses.

Where practicable, the sowing of the winter wheat would have to be delayed as long as possible to prevent the germination of the blackgrass. This however, would be linked to the risk of receiving deteriorated sowing conditions or the possibly necessary switching to summer crops. Due to the very high germination rate of blackgrass, the sawing of winter barley in some regions would be impossible. In the long run the yield depressions could also be much higher than currently assumed. Especially, if consequently the ACC-ase inhibitors based plant protection agents, due to aggravated resistances, would also become ineffective. According to the experts in some areas the sulfonyl ureas as well could become ineffective for treating the currently affected sites. In addition to that, for the coming five years no new active substances can be expected.

Owing to the labor economic necessity, all crops of the crop rotation in the **eastern region** are cultivated using no-plough tillage (mulch-sowing) systems. Therefore, a Glyphosate ban would not necessarily lead to a re-utilization of the plough in this region (Table 2.4). Hence, yield depressions around 10% can be expected. As a reaction to a Glyphosate ban farmers would also incorporate one additional stubble cultivation and apply an additional active substance in the form of a soil herbicide for wheat and a leaf herbicide in case of rapeseed.

Table 2.4: Production changes for the crop rotation in case of a ban on Glyphosate in the Eastern Region

Rotation period	Tillage	Plant Protection	Yield
Rapeseed after Wheat	One additional stubble tilth	One additional leaf herbicide	-10%
Wheat after Rapeseed	One additional stubble tilth	One additional soil herbicide	-10%
Wheat after Wheat	One additional stubble tilth	One additional soil herbicide	-10%

Source: Results of Expert interviews, 2011

For the **summer crops** maize and sugarbeet the adjustments in the three regions Coast, North and South are even more evident, as depicted in Table 2.5.

Table 2.5: Production changes for maize and sugarbeets in case of a ban on Glyphosate in all regions

Region	Crop	Tilling	Plant Protection	Yield
North/ South	Maize	Switching to plough	Higher Sulfonyl ureas application rates	No changes
	Sugarbeet	Switching to plough	No changes	No changes
East	Maize	One additional soil cultivation	Higher Sulfonyl ureas application rates	No changes
	Sugarbeet	One additional soil cultivation	One additional treatment of grasses	- 5%
Coast	Maize	Switching to plough	Higher Sulfonyl ureas application rates	- 10%
	Sugarbeet	Switching to plough	One additional treatment of grasses	- 5%

Source: Results of Expert Interviews, 2011

Farmers in these regions if possible, would like to switch back from no-plough tillage (mulch-sowing) systems to plough tillage. Nevertheless, in the coastal region yield depressions would have to be accepted, as the maize cultivation in this region due to a shortage of arable land is practiced in long-term monoculture. Hence, the twitch-grass would emerge as an issue that due to a resistance-expansion in case of the sulfonyl ureas would be certainly aggravated. The consultants in the Eastern region assume that maize cultivation will not be affected by yield depressions. However, against the background of the expert opinions in the three other regions, due to an increased emergence of resistances in the long run, for the eastern region yield depression ranging from 5% to 10% can be expected. Sugarbeet cultivation using no-plough tillage (mulch-sowing) systems, which would be practiced further on, due to a low tolerance to herbicide applications lead to yield depressions of 5%.

The non-availability of Gylphosate for **pre-harvest treatment** would lead to an increase of the machinery and labor costs in the Eastern Region. Through a more consistent and faster maturation in case of a Glyphosate application the agricultural machines could be better utilized to their capacity and thus capital and labor could be saved. The strict variety guidelines set by the buyers and the orientation of the crop rotation towards a few crops leaves little room for further alternatives to optimize harvest management. In case of a ban on the pre-harvest treatment in the Coastal Region, Glyphosate would have to be increasingly applied for the treatment of stubbles. However, the degrees of action of the active substance in this case would be lower, thus the application rates would have to be increased. In the other regions only a few areas would be affected by a Glyphosate ban. On these areas the treatment with Glyphosate often is the only alternative solution to a total field break up and thus ensures a certain revenue from the site. Furthermore, in order to facilitate a preferably easy stubble treatment, in many cases only weed nests in the cultivated area would be treated. A ban on pre-harvest treatment, thus would lead to an intensification of tillage.

Principally, it can be noted moreover that the cultivation of **intermediate crops** would considerably decline, owing to the fact that an essential weed-suppression is only given at a very dense intermediate-crop-stand level. Furthermore, an ensured freezing-off of the intermediate crops has to be given. An establishment of undersown crops in maize would also be only possible with limitations, as the stands after the maize harvest so far are killed using Glyphosate based plant protection agents. The participation in agri-environmental-measures, that support the cultivation of mulch-sown or undersown crops, would inevitably also drop back or alternatively for the farmers to participate, higher premiums would have to be guaranteed. The direct drilling system which is used on approximately 1.4% of the arable land in most areas would not be possible without the application of Glyphosate. Furthermore, the establishment of newer cultivation methods in tillage, as for example the strip-till-procedure, which is devoted to the reduction of erosion, fuel and labor input, would be complicated.

Mulch-sowing in case of a Glyphosate ban

In the foregone scenarios so far for the regions North, Coast and South it has been assumed that the plough is applied once during the tripartite crop rotation. However, there are also areas that for example, because of their attached risk of being prone to erosion or their high clay content cannot be ploughed. For these areas significantly higher yield depression would have to be expected.

The high pressure through weeds would cause average mid-term yield depressions of 10% for winter cereals and winter rapeseed cultivation. However, considerable regional differences would exist. Thus, particularly in the coastal region on certain areas crop farming would not be possible anymore. But also in the northern region on areas with widespread herbicide resistances to blackgrass and bent-grass, yield depressions ranging from 20% to 30% could be possible. Therefore, some experts as a consequence recommend incorporating more summer crops in the crop rotation.

On sites that are cultivated using exclusively conservation-tillage systems, in most cases two additional tillage-operations would have to be incorporated and the sowing-periods would be delayed further back. Furthermore, in case the “green bridge” would not be broken up successfully, the stubble wheat in many cases would have to be treated through an increased fungicide application and partly the application of insecticides to control aphids and frit-fly would become necessary. A survival of the volunteer cereals in winter barley cultivation can stimulate the yellow dwarf virus.

The yield depressions in the case of the summer crops maize and sugarbeet have to be considered using a differentiated approach. For maize cultivation in the northern and southern regions the experts reckon with yield depressions of 5%. In the Eastern region in short-term no yield-depressions would occur, whereas the cultivation using no-plough-tillage (mulch-sowing) would not be possible in the Coastal Region. In the three regions North, South and East the aggravated pressure from weeds could be dealt with by using two additional tillage-operations and by the increased use of Gramicides within the vegetation period. However, the increased use of sulfonyl ureas could aggravate the development of resistances against this particular active substance group and ultimately lead to long-term yield depressions. On some sites that due to an increased risk of erosion so far have been cultivated using no-plough tillage (mulch-sowing) systems, farmers would even abandon maize cultivation if the threat from weeding would become too big.

The cultivation of sugarbeet using no-plough tillage (mulch-sowing) systems would on average also lead to yield depressions of 5%. However, the yield depressions would be very much dependent on the crop rotation. The incorporation of winter rapeseed and sugarbeet into a crop rotation without the use of Glyphosate is certainly more difficult, as the emerging volunteer rapeseed in sugarbeet cultivation would be difficult to control. Therefore, farms in the eastern region would partially cut back on sugarbeet cultivation. The no-plough tillage (mulch-sowing) system in sugarbeet cultivation in some areas in the northern region has even lead to yield increases. However, this system is only possible if the pressure from weeds is not very high and additional summer crops as a reaction to a Glyphosate ban are incorporated in the crop rotation. Otherwise, the experts depending on the individual regions reckon with considerable yield depressions ranging from 5% to 40%.

3 Results of the Agroeconomic Calculations

The influences from a ban on the active substance Glyphosate on the farmers in Germany are analyzed on the basis of the profit margin calculation. Thereby, on one hand the standardized crop rotation winter rapeseed / winter wheat / winter wheat and on the other hand the summer crops maize and sugarbeet, are considered separately.

Yields and prices

The yields [dt/ha (quintal/ha)] for wheat, barley, rapeseed, sugarbeet and maize correspond to the average for the years 2006 to 2010. They are obtained from the statistics of the statistical state offices and differentiated through assigning the federal states to the corresponding regions (Statistisches Bundesamt, 2011). The prices [Euro/dt] correspond to the average of the years 2006/07 to 2010/11. Until 2009/10 they originate from the AMI Market Report 2011 (AMI, 2010) and for 2010/2011 are based on an own projection with the help of the AMI producer prices and deliberations of the BMELV from 06/2011 (BMELV, 2011a).

Table 3.1: Yields (dt/ha) for wheat, rapeseed, maize and sugarbeets in the individual regions of Germany (average value 2006 to 2010)

Crop / Region	Wheat	Barley	Rapeseed	Maize	Sugarbeet
Coast	89.2	80.0	41.6	87.0	580
North	83.0	73.3	38.0	90.0	622
East	71.7	65.9	37.9	79.6	570

Source: Statistisches Bundesamt, 2011

Table 3.2: Prices (Euro/dt) for cereals, rapeseed, maize and sugarbeets in Germany (average value 2006/07 to 2010/11)

	Wheat	Barley	Rapeseed	Maize	Sugarbeet
Price	16.2	14.1	32.1	16.2	2.63

Source: AMI Market Report 2011 and BMELV 2011a

With the help of the multi-product-multi-region model AGRISIM (see Chapter 4) the increases in producer prices induced by possible europe-wide yield depressions and cost increases have been calculated (Table 3.3). In the five scenarios possible average yield depressions in Europe which can range from 0% to 20% are considered, whereas the cost increases are averaged over the regions and remain constant.

Table 3.3: Price increase due to yield depressions and costs increases - results from the model AGRISIM

Yield depression	Price increase in %				
	Wheat	Barley	Rapeseed	Maize	Sugarbeet
0 %	0.79	1.02	0.97	0.24	0.04
-5 %	2.15	2.24	1.87	0.79	0.17
-10 %	3.54	3.53	2.79	1.35	0,30
-15 %	4.95	4.82	3.73	1.91	0.44
-20 %	6.42	6.17	4.69	2.49	0.58

Source: own calculation using AGRISIM

Cost factors and profit margin calculation

The direct costs in the profit margin calculation consist of the fertilizer costs and the costs for plant protection agents. The fertilizer costs are obtained from the Statistical Yearbook 2010 and correspond to the three-year-average 2006/07 to 2008/09 of the pure nutrients (BMELV, 2011b). The fertilizer use per hectare has been calculated after withdrawal. Based on the expert interviews and the recommendations for 2011 by the chambers of agriculture and the state institutes for agriculture in Schleswig-Holstein, Niedersachsen, Nordrhein-Westfalen and Mecklenburg-Vorpommern the different plant protection strategies have been developed. The costs for the plant protection agents correspond to the purchasing prices of the agricultural enterprises in spring 2011.

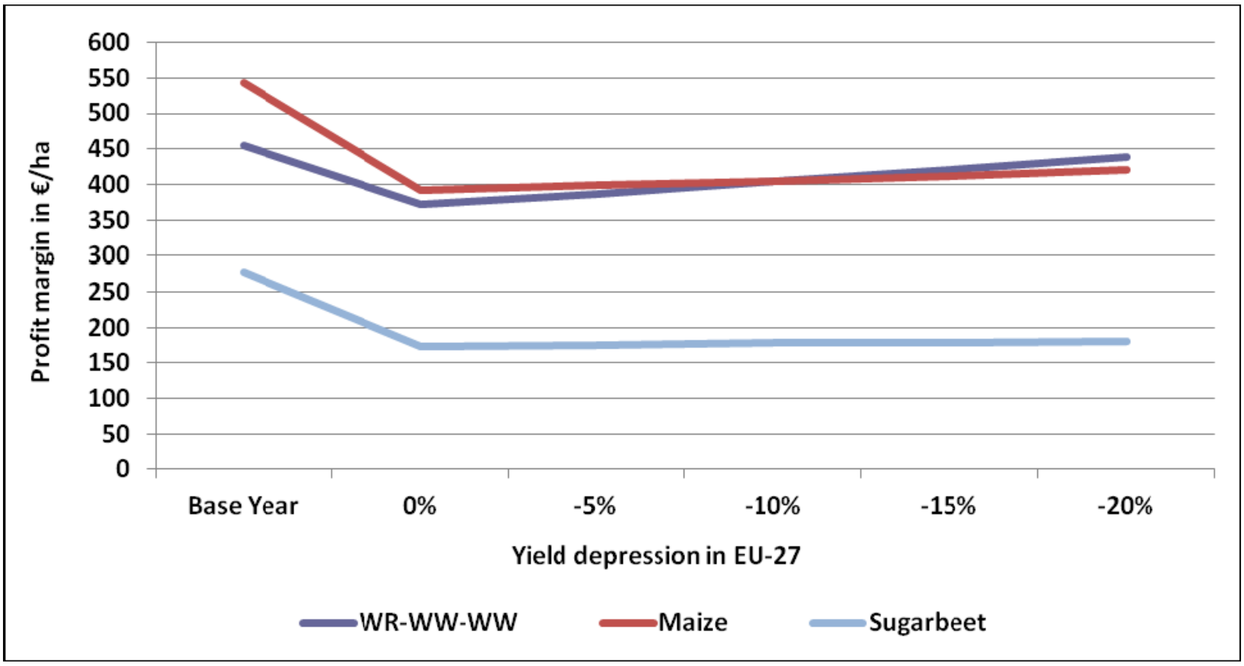
Furthermore, the working costs consisting of machinery and labor costs are considered. They are based on the information provided by the Associaton for Technology and Structres in Agriculture (KTBL, 2011). For a better comparability, the total fixed and variable machinery costs are considered, so that a comparison between a self-mechanized enterprise and an enterprise hiring contractors can be facilitated.

Impacts on the profit margins in the different regions

The profit margins for the analyzed crops in the three regions under the assumption of yield depressions between 0% and -5% are negatively affected in case of a ban on

Glyphosate. Solely maize cultivation in the northern region through the improved price situation and the absence of yield depressions manages to achieve a higher profit margin.

Figure 3.1: Change of profit margins due to a ban on Glyphosate in the Coastal Region

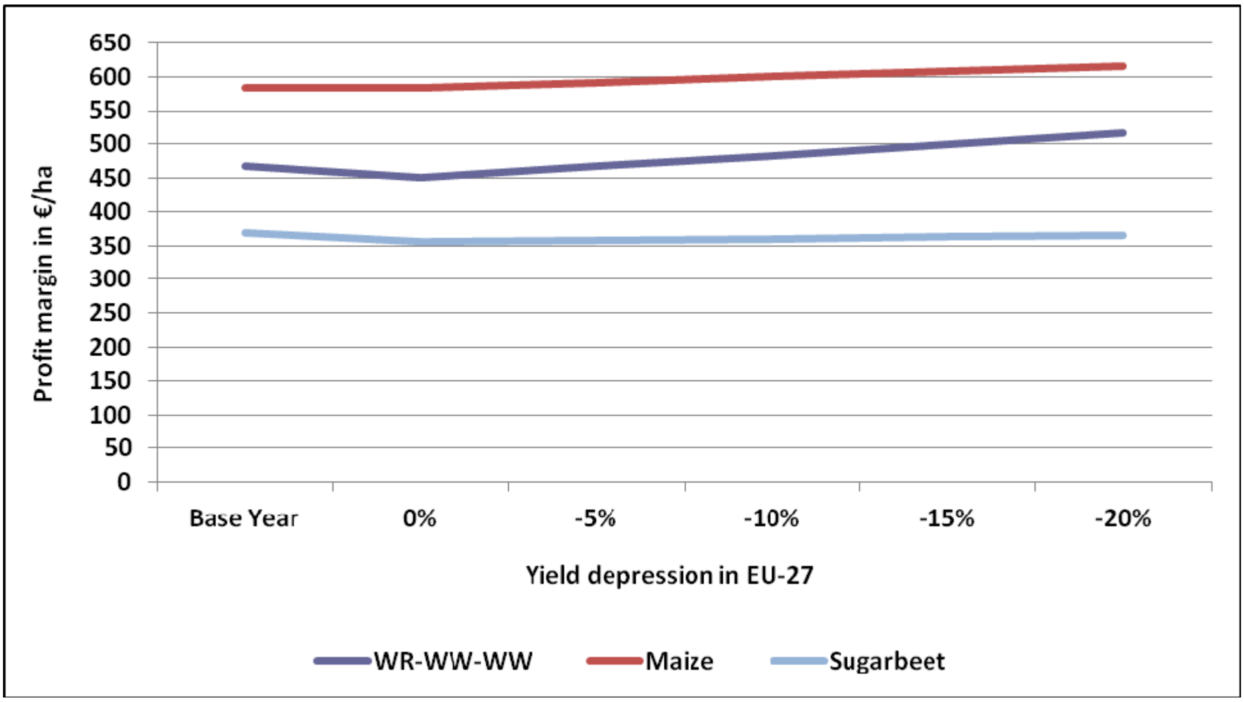


Source: own calculations

In the **coastal region**, particularly through yield depressions of 5% for the crop rotation, 10% for maize and 5% for sugarbeet, but also through additional tillage and increased plant protection expenses or the switching to inversion tillage for maize and sugarbeet respectively, the profit margins are substantially reduced (Figure 3.1). Under the assumption that on an European-average yield depressions for all crops of 5% can be expected, the profit margin for the crop rotation winter rapeseed / winter wheat / winter wheat reduces by 14.7%, for the maize cultivation by 26.7% and for the sugarbeet cultivation by 36%, respectively. In case these yield depressions in the other regions of Europe should be significantly higher than 5%, though prices would increase, the profit margins would always be considerably lower than in the initial scenario. For the cultivation of winter barley the same conditions concerning the cost increases apply as in the case of winter wheat cropping. Due to the early sowing of the winter barley yield depressions in blackgrass areas can be slightly higher.

In the two **regions of North and South**, according to the experts, there are no yield depressions, to be expected solely the production costs would increase. Therefore, the losses due to the higher costs, for the most part can be compensated by the higher prices. With an average yield reduction of 5% in Europe, only the profit margin for the cultivation of sugarbeet is reduced by 2.9% (Fig. 3.2). The profit margin for the crop rotation can be kept constant, while maize cropping allows for 1.5% higher profit margins. The cultivation of winter barley is largely unaffected by cost increases, as it is grown within the crop rotation usually after winter wheat and is then ploughed beforehand.

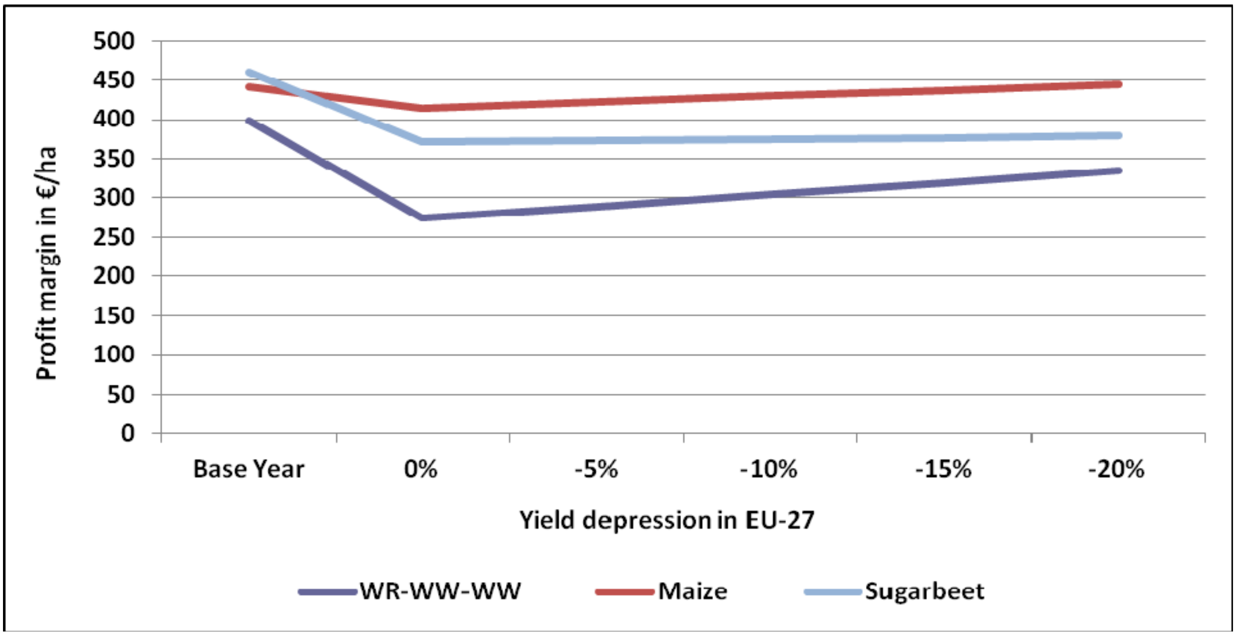
Figure 3.2: Change of profit margins due to a ban on Glyphosate in the Northern Region



Source: own calculations

In Chapter 2 it was already shown that due to the continuing existence of mulch-sowing in the Eastern Region, the highest yield depressions can be expected, 10% for the crop rotation and 5% for sugarbeet, respectively. Only maize cultivation is possible without encountering yield depressions. Therefore, strong profit margin fluctuations are caused over here. Under the scenario of a Europe-wide yield depression of 5% profit margin reductions for the crop rotation to the tune of 27.6%, for maize 4.2% and for sugarbeet 19%, can be expected respectively (Figure 3.3).

Figure 3.3: Change of profit margins due to a ban on Glyphosate in the Eastern Region



Source: own calculations

Change in working costs

The biggest changes in case of a ban on Glyphosate affect the working costs. At the same time, due to the consistently growing farms and the often required outside-capital investment and the increased number of part-time farms, primarily the labour costs are a crucial factor. For all three regions an increase in the machinery costs as well as the labor costs between 5% to 11% can be seen (Figure 3.4 and 3.5). In absolute value that corresponds up to 30 Euro/ha for the machinery costs and 8 Euro/ha for the labour costs or half an hour per hectare additional labour, respectively.

Fig. 3.4: Increase of the machinery costs due to a Glyphosate ban

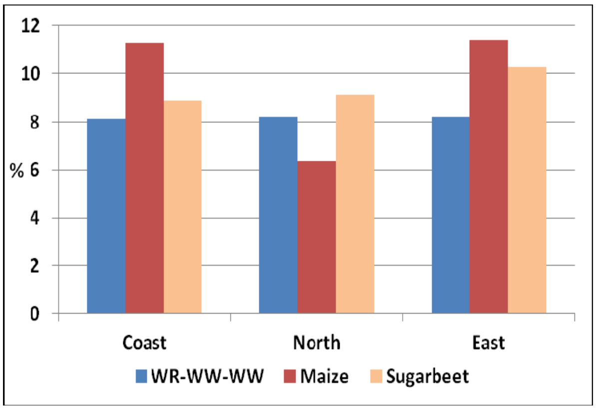
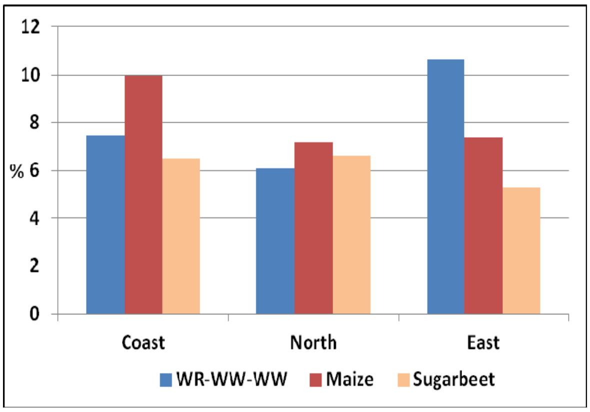


Fig. 3.5: Increase of the labour costs due to a Glyphosate ban



Source: own calcuations

Profit margin impacts for specialized mulch-sowing farms in the Northern Region

In the calculations so far, based on the assessments of the regional experts for the Northern Region only farms have been considered that use the plough once in crop rotation and also in other mechanization are not specialized in mulch-sowing. Therefore, in following it is analyzed how the profit margin changes for the crop rotation winter rapeseed / winter wheat / winter wheat, when a purely mulch-sowing practicing farm has to renounce Glyphosate based plant protection agents. As a consequence, according to the view of the experts, the plough would have to be used once again. Thereby in mid-term, yield depressions could certainly be prevented. For winter rapeseed and for winter wheat after winter rapeseed a more intensive tillage and an intensification of the herbicide treatments follow.

The findings are revealed in Table 3.4. The profit margin, under consideration of the price increases in case of the scenario 0% yield depression, decreases by 7%. Particularly clearly the effects can be seen in case of the working costs. The machinery costs increase by 14% and the labour costs by 18%, respectively.

Table 3.4: Profit margin calculation for specialized mulch-sowing farms in the Northern Region

	With Glyphosate Application	Without Glyphosate Application	Change
Output (€/ha)	1303	1313	+0.8%
Direct Costs (€/ha)	513	512	-
Machinery Costs (€/ha)	241	275	+14.0%
Working Costs (€/ha)	61	72	+18.0%
Total variable costs (€/ha)	815	859	+5.4%
Profit Margin (€/ha)	488	454	-7.0%

Source: own computations based on the expert survey conducted and KTBL-Data

4 Results of the sectoral analysis

So far the effects of a ban of Glyphosate 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 and cost increases due to a ban on Glyphosate under different assumptions of farmers' responses. 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	Argentina
Coarse Grain	Brazil
Rice	Canada
Maize	China
Oilseeds	EU-27
Soybeans	India
Sugar	Japan
Milk	Mexico
Beef	Russia
Pork	South Africa
Poultry	Ukraine
	United States
	Rest of Europe
	Rest of the World

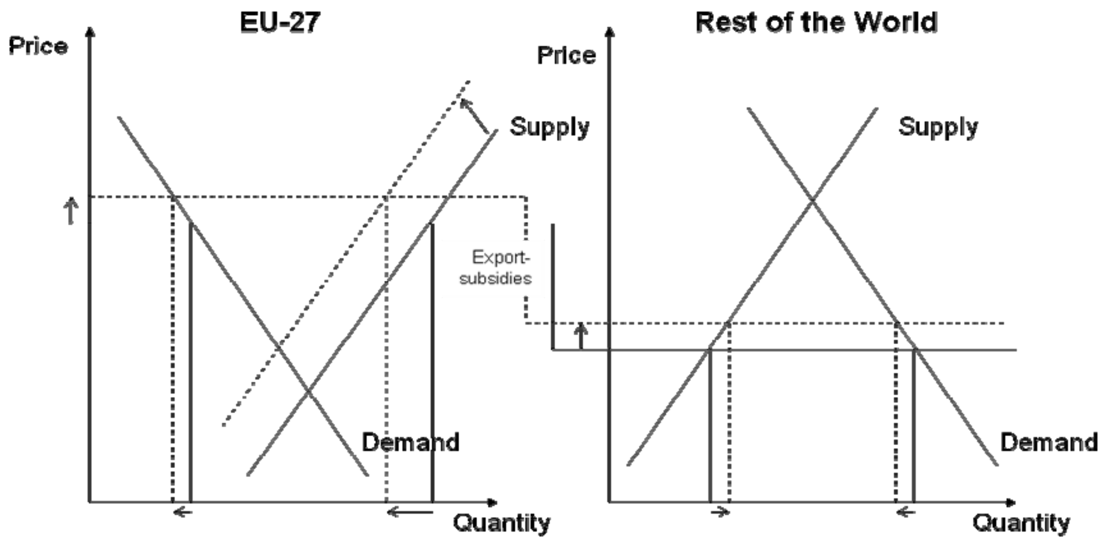
Data Sources from FAO, OECD, USDA, SWOPSIM/ERS/USDA for 2006

The principal functioning of the model and the sectoral effects of a policy-driven yield loss and cost increase 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 and cost increases 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:

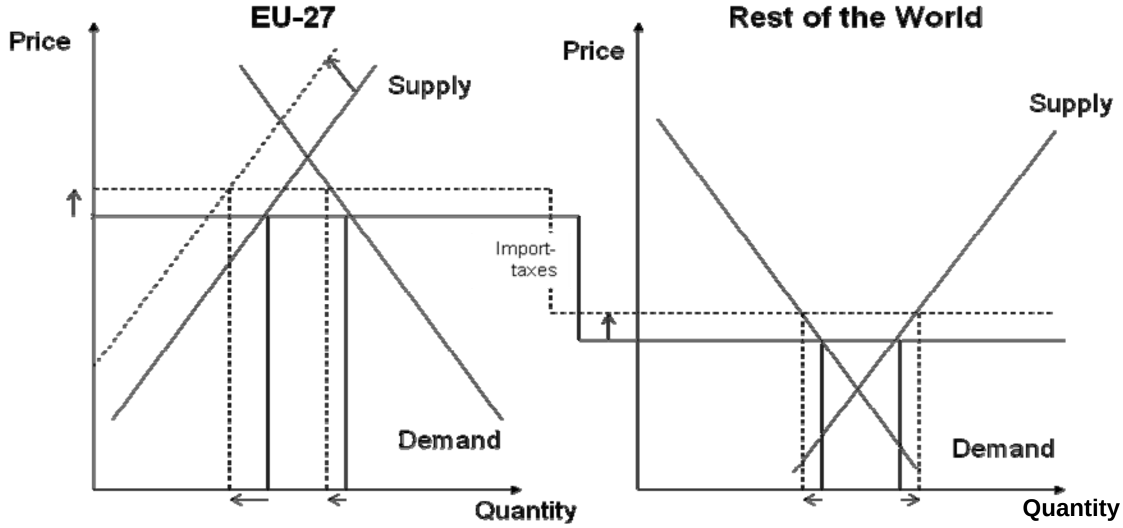
- A decline of EU production which is partly offset by a slight price increase;
- a decline of EU consumption;
- higher domestic and world market prices;
- an increase of production and a decrease of consumption in the rest of the world
- and finally depending on the trade structure of both regions a 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 20% with corresponding cost adjustments for wheat, coarse grains, maize, oilseeds and sugar 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 minimum of 1.6% and a maximum of 13.3%, coarse grain production decreases between 2.6% and 13.6%, maize between 0.1% and 14.6%, oilseeds between 3.8% and 16.8% and sugar between 1.1% and 15.9%.
- **Trade effects in the EU-27** (Figures 4.2 b – 4.6 b):
  The net-trade position for wheat under different scenarios changes from an export status of 8.7 million tonnes to an import status of 6.3 million tonnes. The same result holds for the coarse grain net-trade position changing from an export status of 3.1 million tonnes to an import status of 5.6 million tonnes. The net imports of oilseeds (maize) increase from 0.6 (2.2) million tonnes to a maximum of 3.7 (11.7) million tonnes, where as the sugar net export decreases from 4.9 to 1.5 million tonnes.

- **Global production and trade shares** (Figures 4.7 – 4.11):
  The wheat production share of the EU-27 would decline from 20.9% to 18.4% and the USA, Mexico and India are the main beneficiaries. The USA and China especially benefit from the change in the EU wheat trade status. The oilseed production share of the EU-27 declines from 29.2% to 25.3% again with advantages for the Americas. The coarse grain and maize production shares are similary affected. The sugar production share of the EU-27 declines from 14.8% to 12.6% 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.

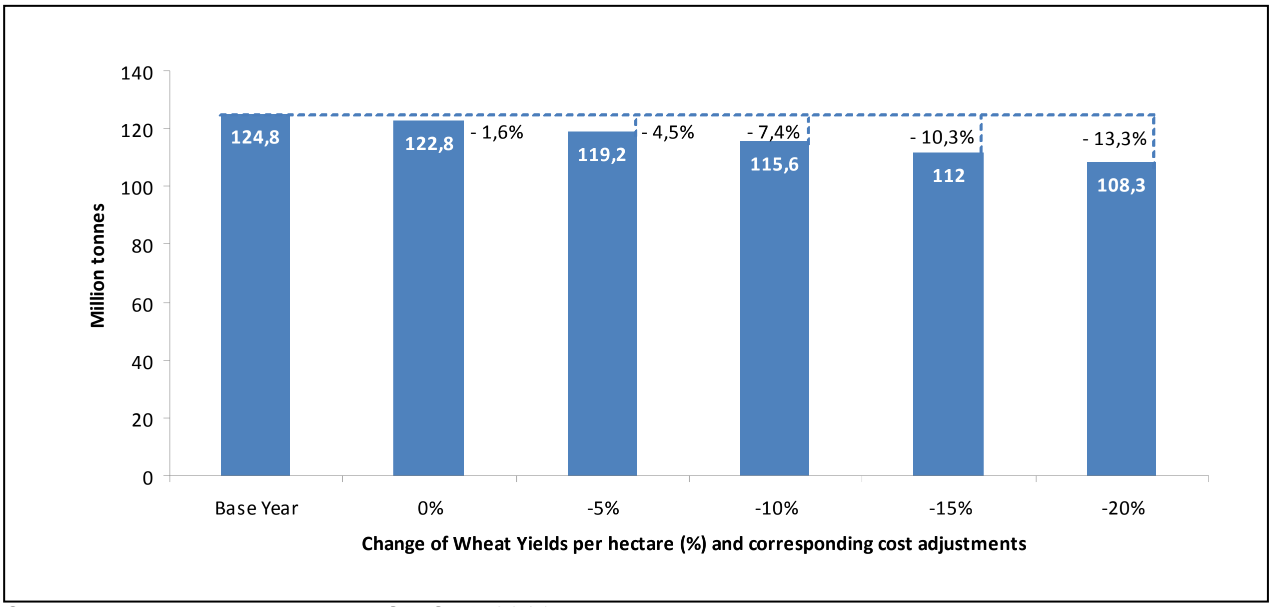
EU-27 production and trade effects

The impact of reduced yields and increased costs due to a ban of Glyphosate 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.

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. 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 and corresponding cost adjustments. The same situation would be observed for 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, where as the sugar net-trade surplus decreases.

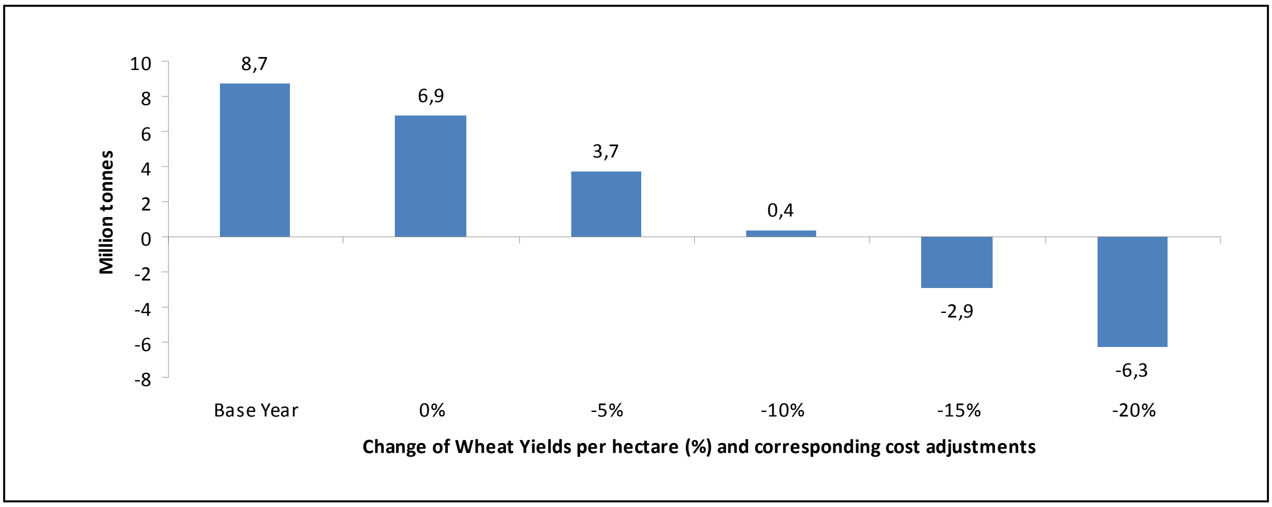
Figure 4.2: Effects of Glyphosate ban in the EU-27

a) on EU wheat production



Source: own calculation using AGRISIM, 2011

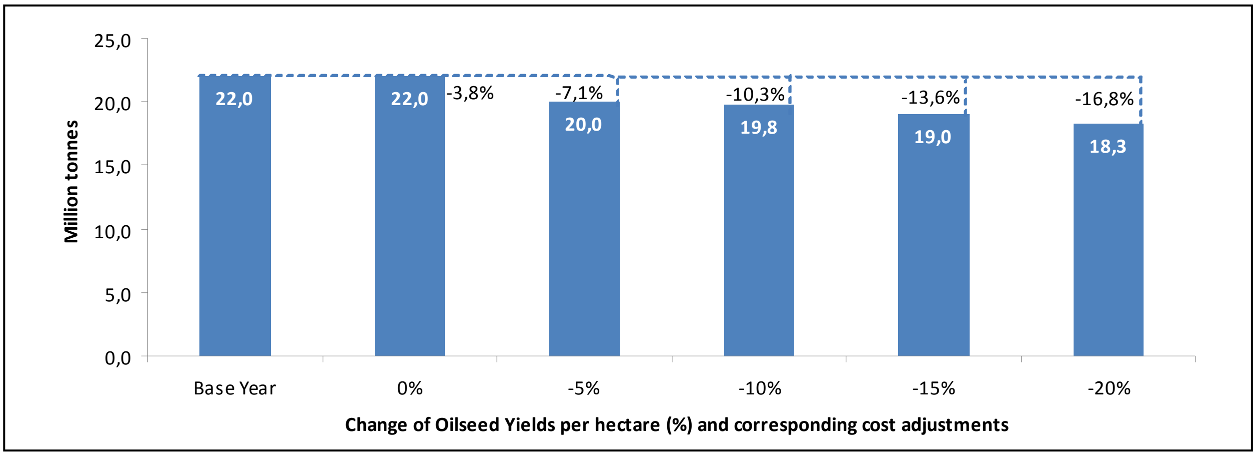
b) on EU wheat net-trade (export minus import)



Source: own calculation using AGRISIM, 2011

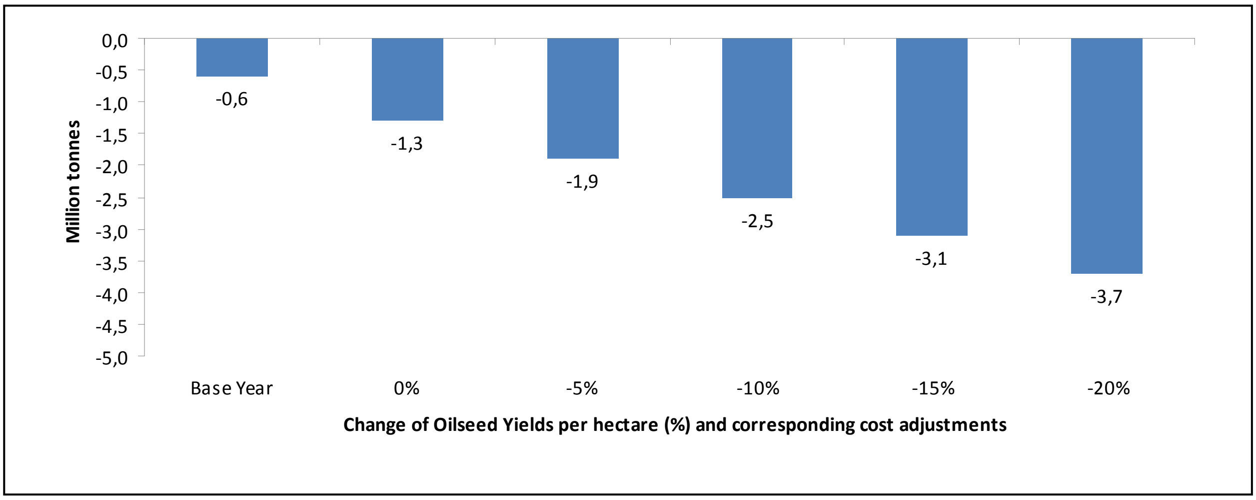
Figure 4.3: Effects of Glyphosate ban in the EU-27

a) on EU oilseed production



Source: own calculation using AGRISIM, 2011

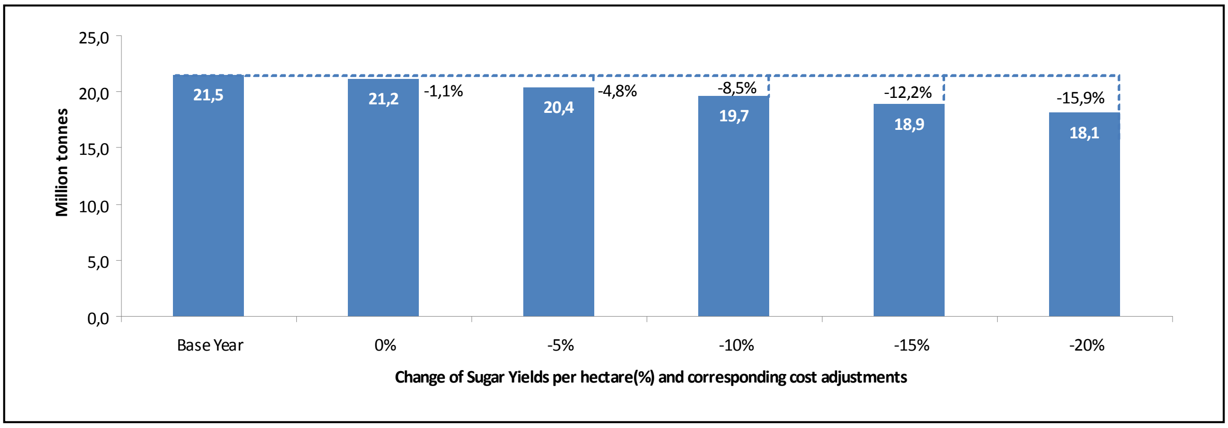
b) on EU oilseed net-trade (export minus import)



Source: own calculation using AGRISIM, 2011

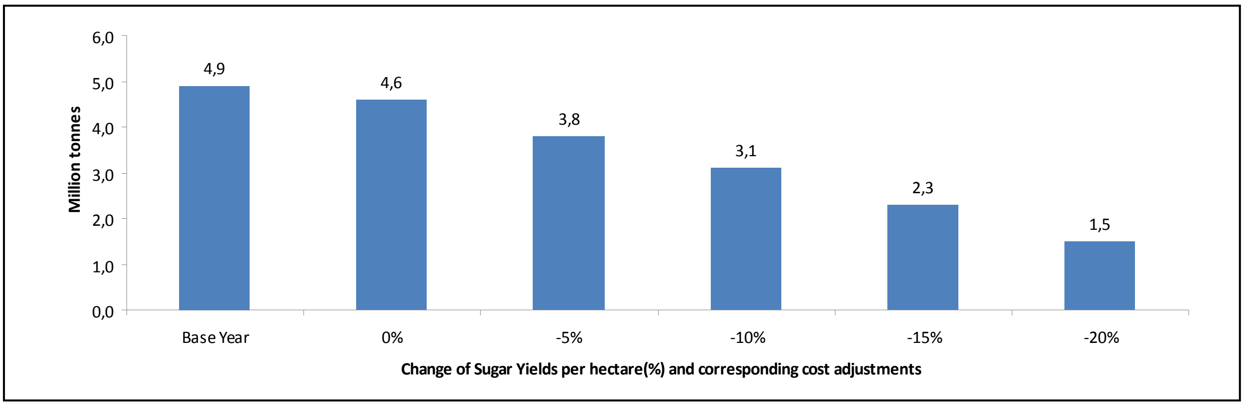
Figure 4.4: Effects of Glyphosate ban in the EU-27

a) on EU sugar production



Source: own calculation using AGRISIM, 2011

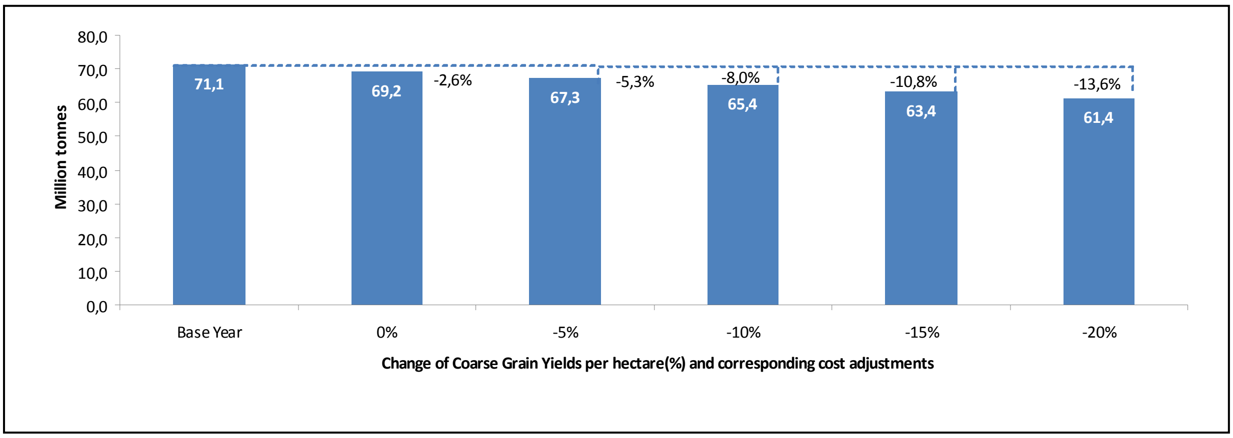
b) On EU sugar net-trade (export minus import)



Source: own calculation using AGRISIM, 2011

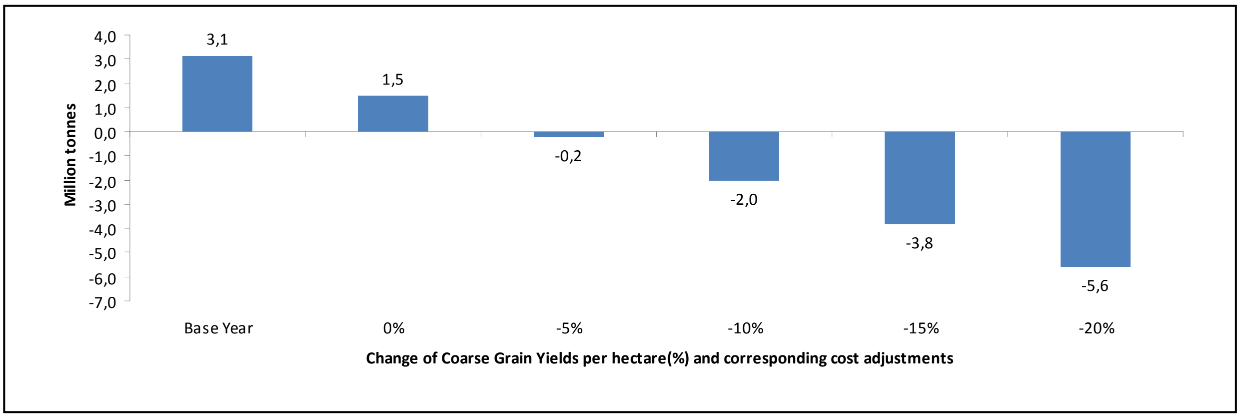
Figure 4.5: Effects of Glyphosate ban in the EU-27

a) on EU coarse grain production



Source: own calculation using AGRISIM, 2011

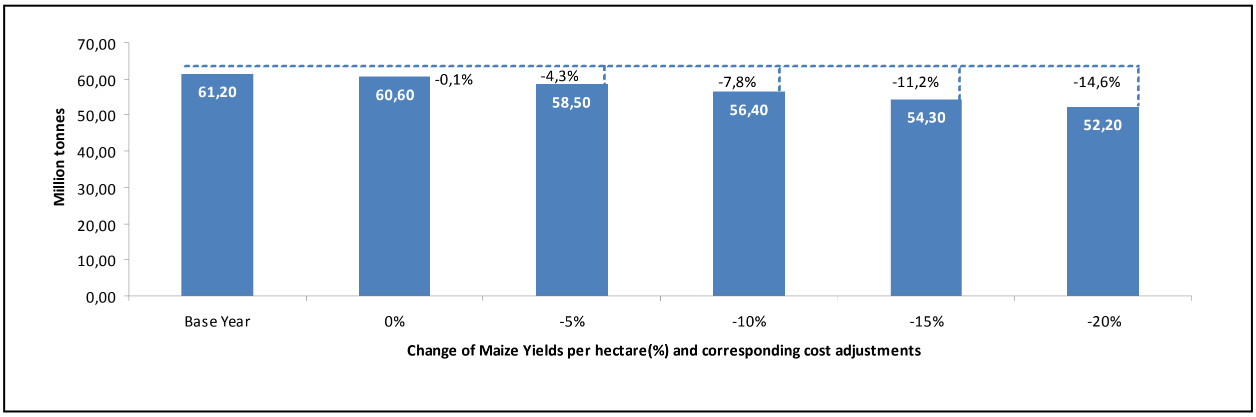
b) On EU coarse grain net-trade (export minus import)



Source: own calculation using AGRISIM, 2011

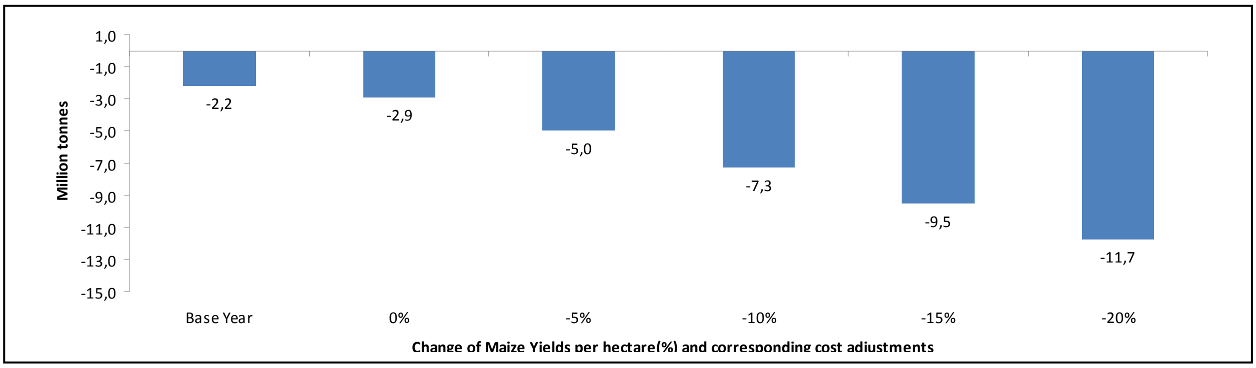
Figure 4.6: Effects of Glyphosate ban in the EU-27

a) on EU maize production



Source: own calculation using AGRISIM, 2011

b) on EU maize net-trade (export minus import)



Source: own calculation using AGRISIM, 2011

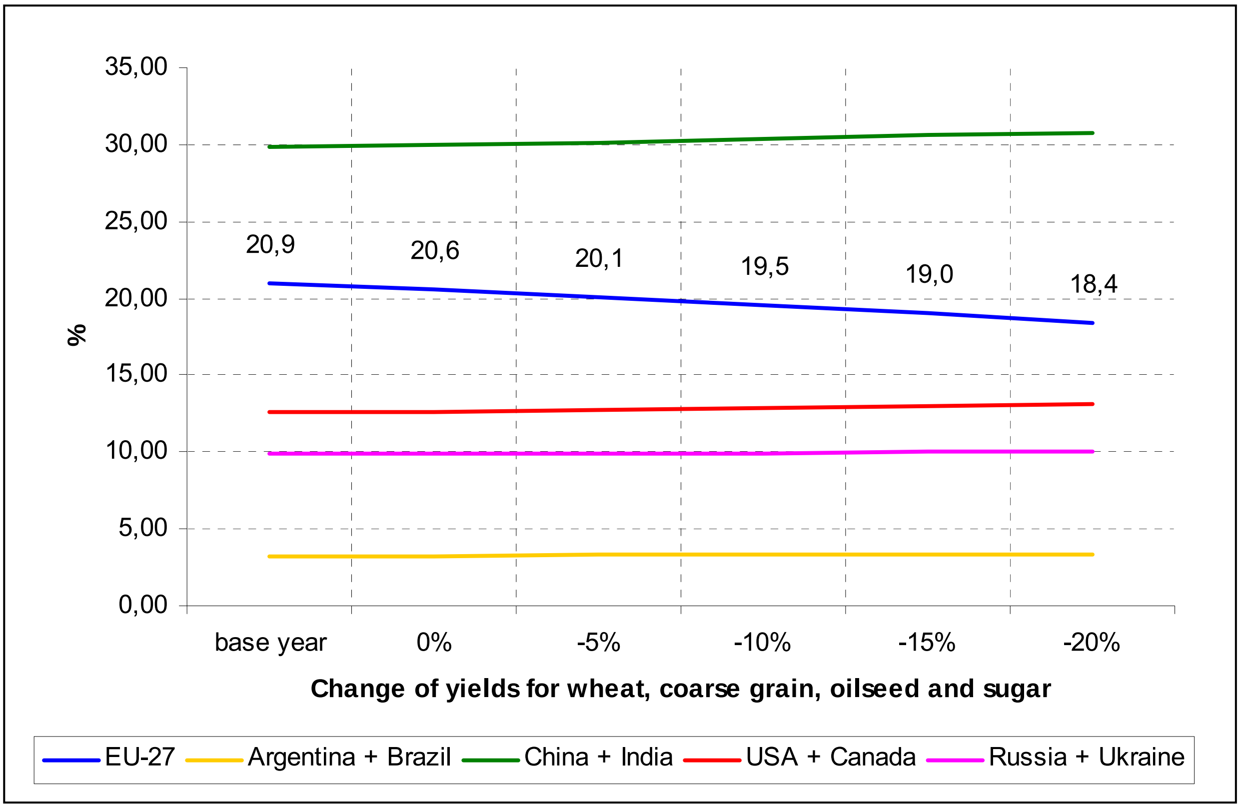
Changes in EU-27 shares in global production

Given that the EU-27 either shifts from a net export to a net import position for wheat, and coarse grains, increases its net import position in the case of oilseeds and maize, and decreases its net exports for sugar 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 India, China and the USA. 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.

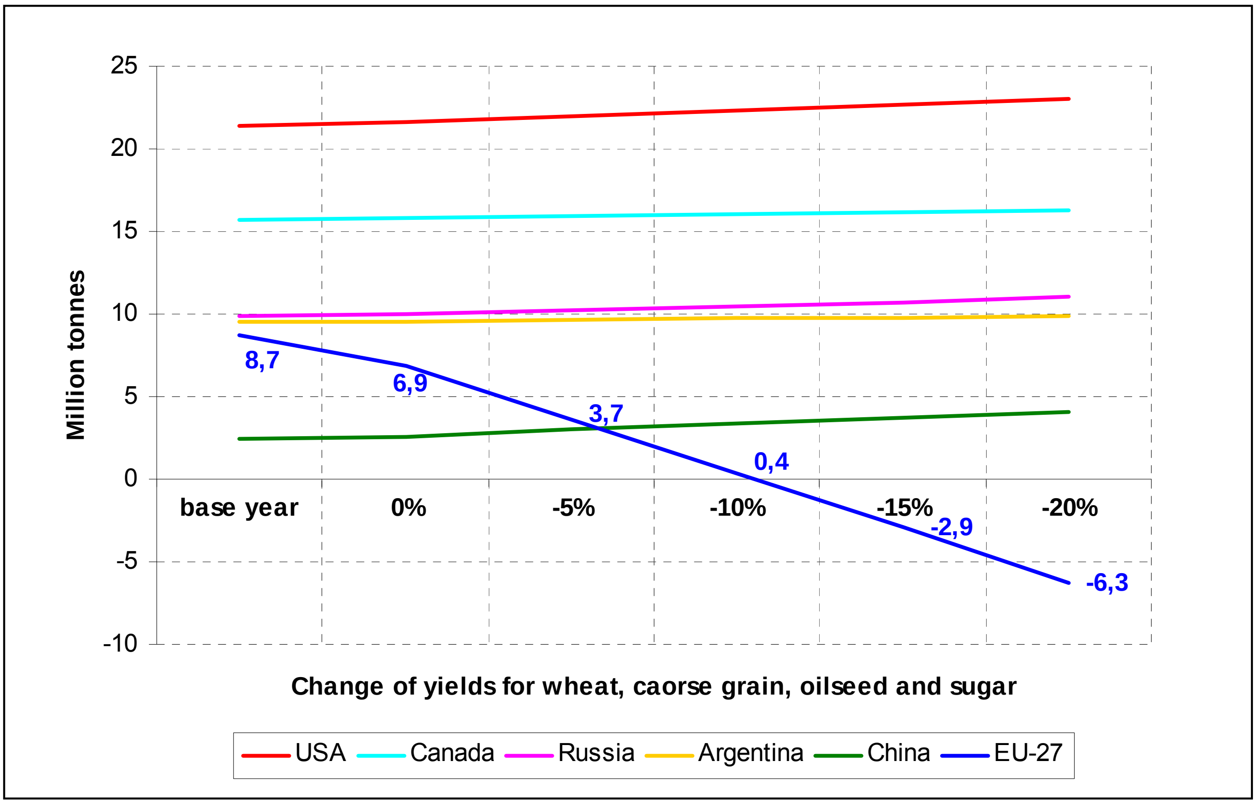
Production shares for coarse grains do change similarly to the wheat case, given the nearly same negative shock to EU-27 production. Again, there would be changes to world trade flows, with USA, Canada and South America gaining in terms of net exports. Sugar production would shift towards South Africa 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



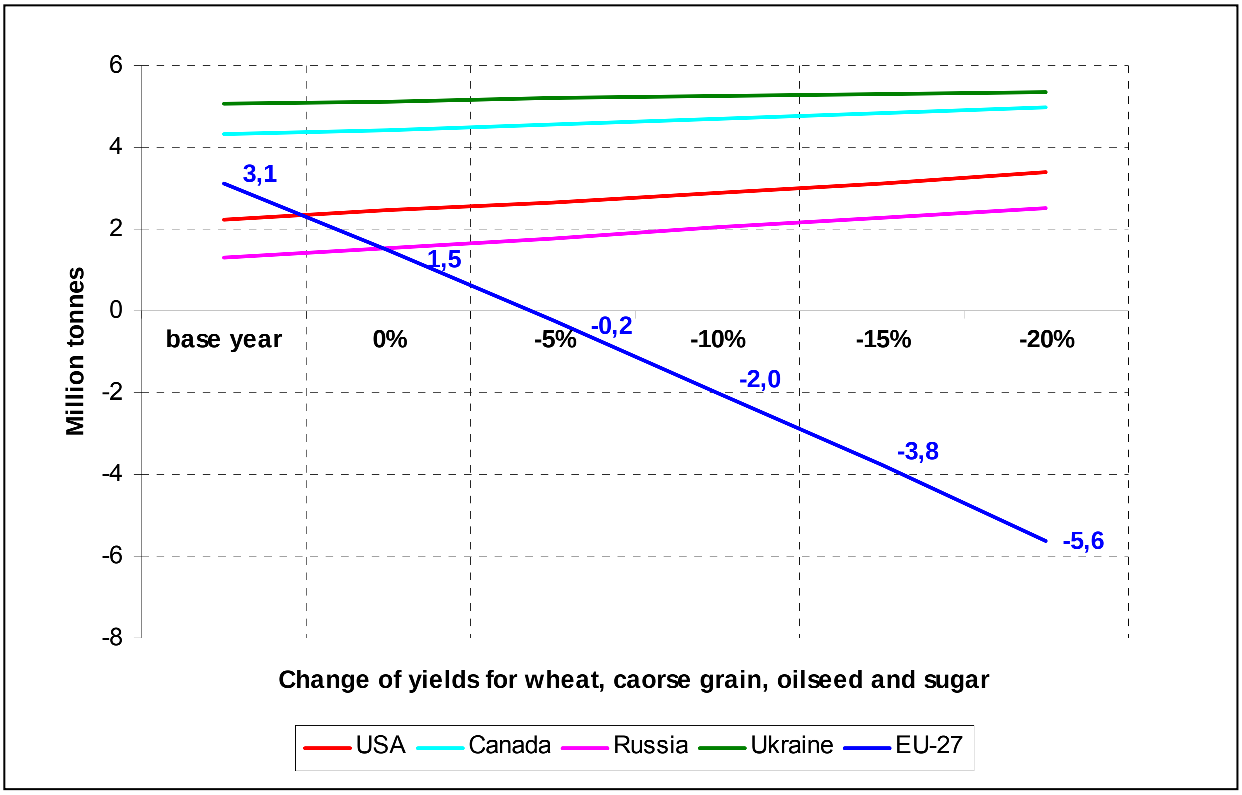
Source: own calculation using AGRISIM, 2011

Figure 4.8: Net-trade of wheat for selected countries/regions



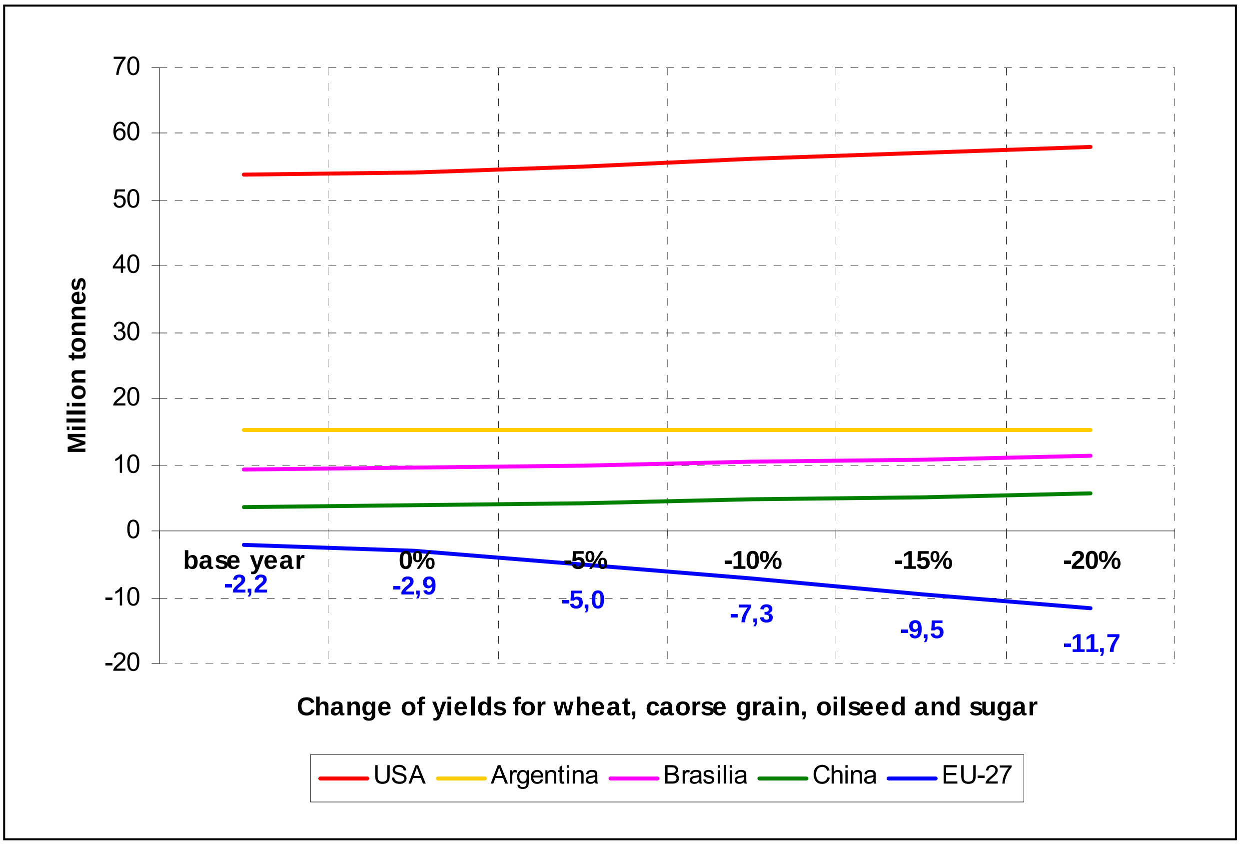
Source: own calculation using AGRISIM, 2011

Figure 4.9: Net-trade of coarse grains for selected countries/regions



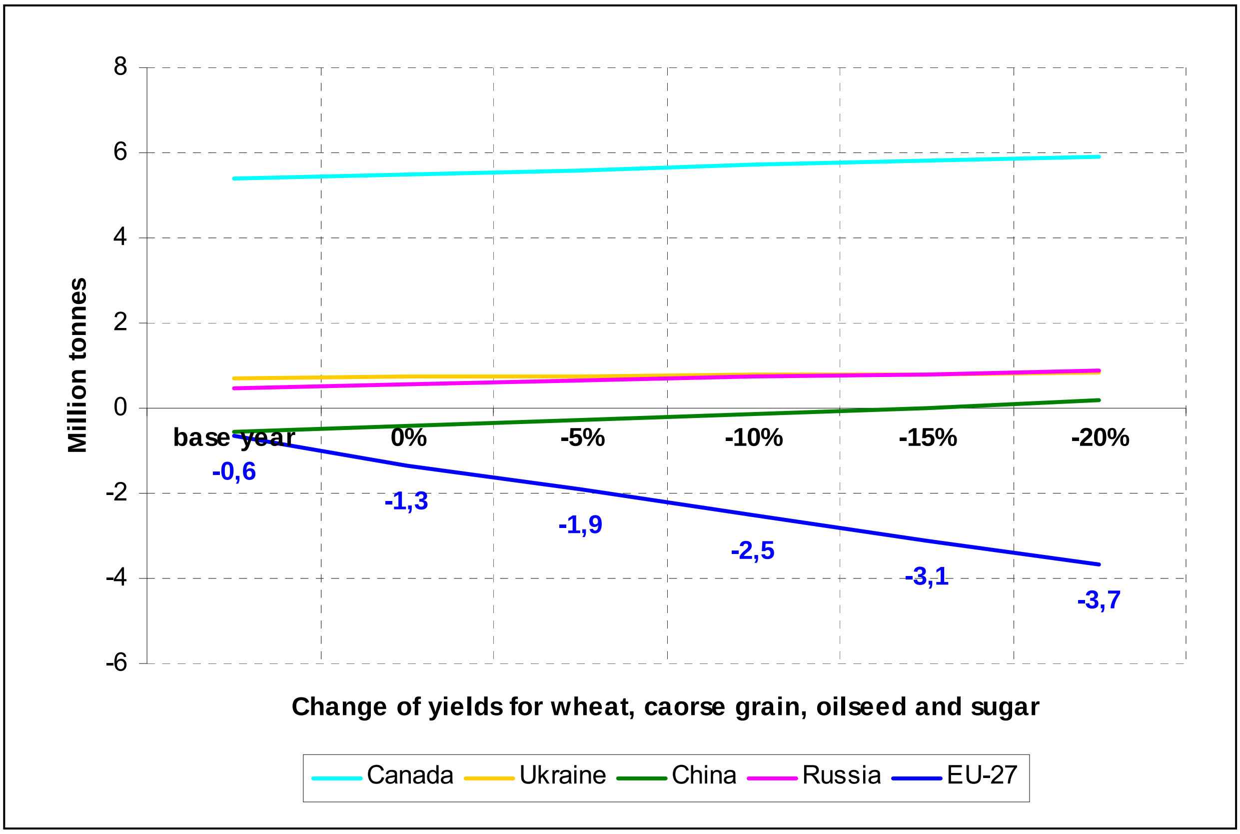
Source: own calculation using AGRISIM, 2011

Figure 4.10: Net-trade of maize for selected countries/regions



Source: own calculation using AGRISIM, 2011

Figure 4.11: Net-trade of oilseed for selected countries/regions

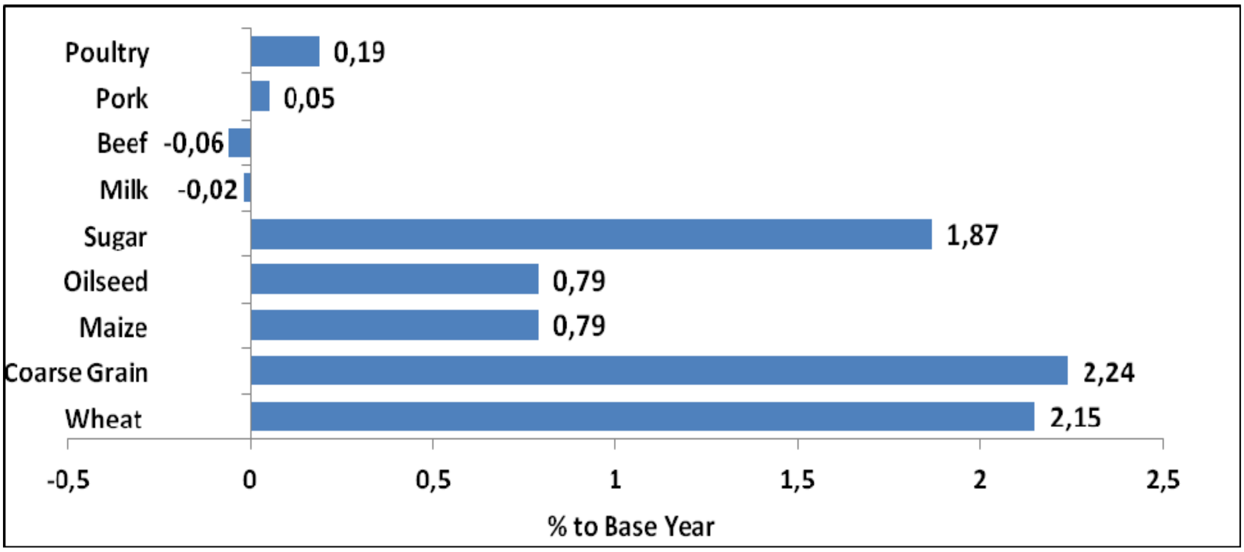


Source: own calculation using AGRISIM, 2011

EU-27 price effects

The largest impact on EU farmgate prices would be experienced by wheat and coarse grain growers (prices would increase by 6.42% and 6.17%) as well as by oilseed farmers (up 4.69%). 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 4.12).

Figure 4.12: Effects of Glyphosate ban in the EU-27 on EU farm gate prices of selected commodities (change due to a 5% yield reduction)

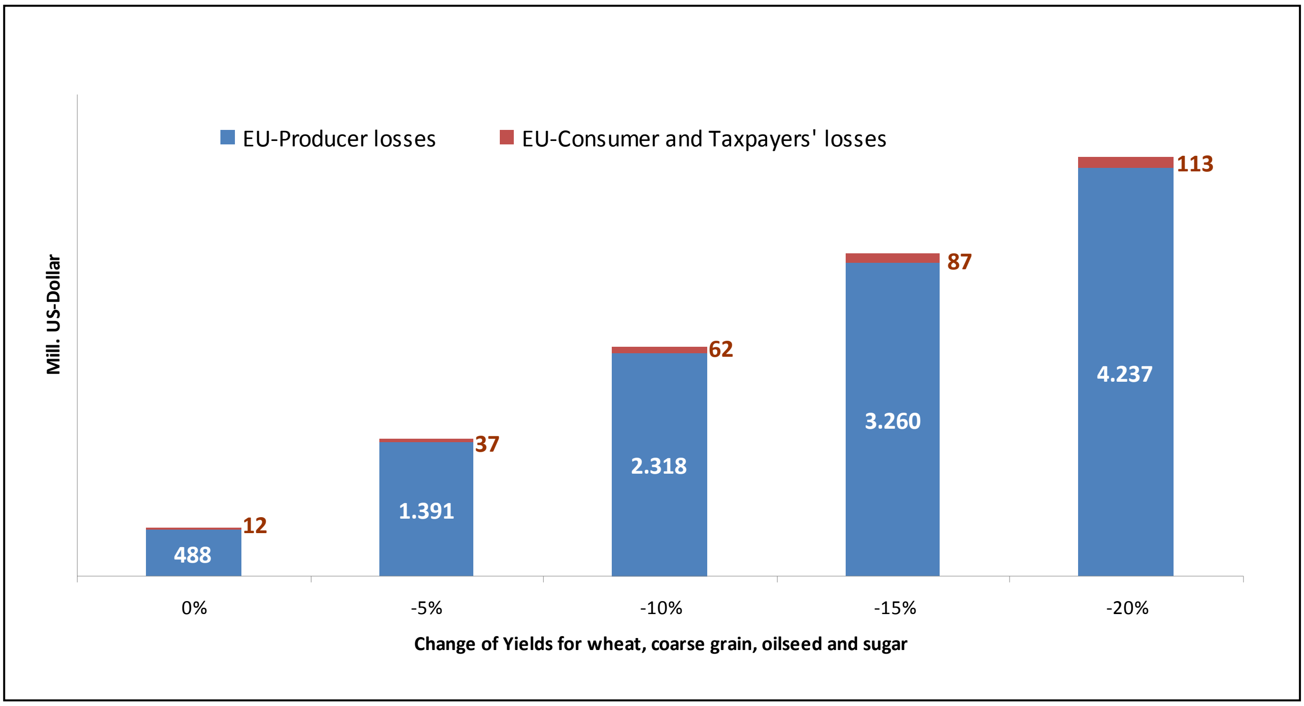


Source: own calculation using AGRISIM, 2011

Welfare effects for EU-27 and other countries

The impact of different assumed yield reductions and corresponding cost adjustments on economic welfare in the EU-27 is shown in Figure 4.13. 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 ban on the use of Glyphosate. However, these higher prices would also adversely affect the welfare of consumers. Also taxpayers would suffer because savings in export subsidies are lower than the losses in tariff revenue on imports, though 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 4.2 billion.

Figure 4.13: Total annual welfare losses due to a Glyphosate ban in the EU-27

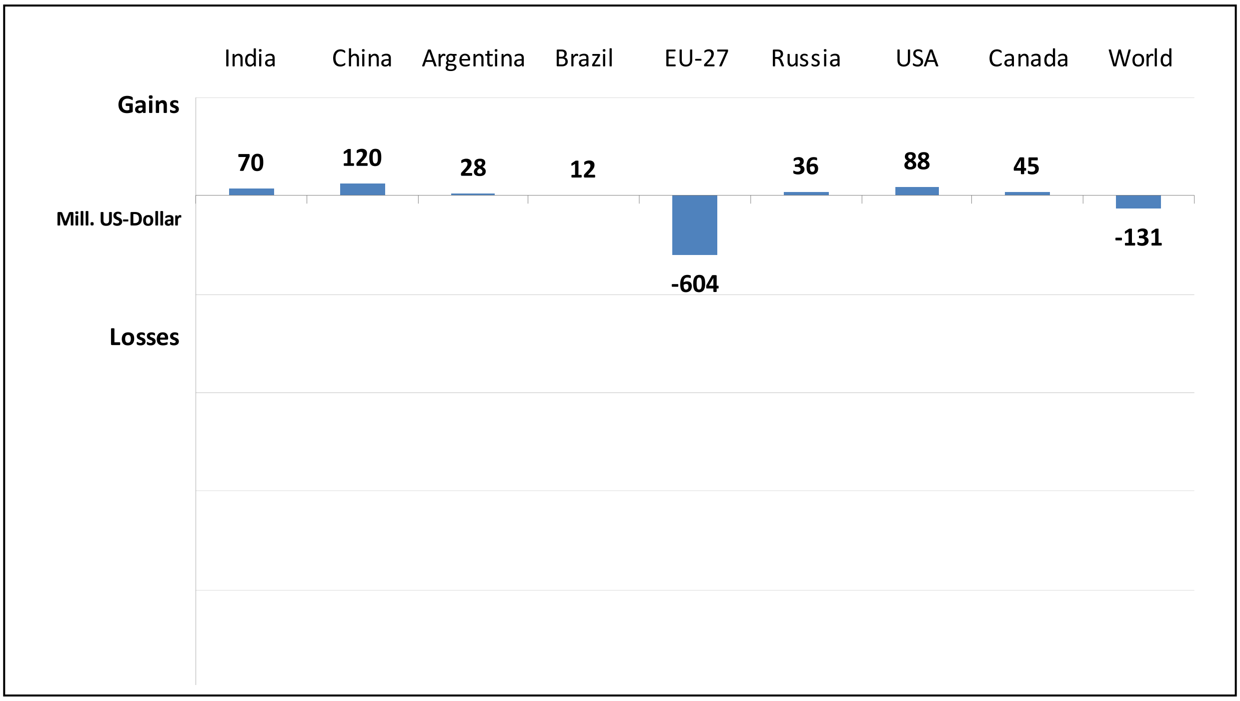


Source: own calculation using AGRISIM, 2011

The welfare impacts on third countries are shown in Figure 4.14 (a) to 4.14 (e), for an intermediate scenario where yields are assumed to fall by 10% in Figure 4.14 (c). 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, China and USA 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.

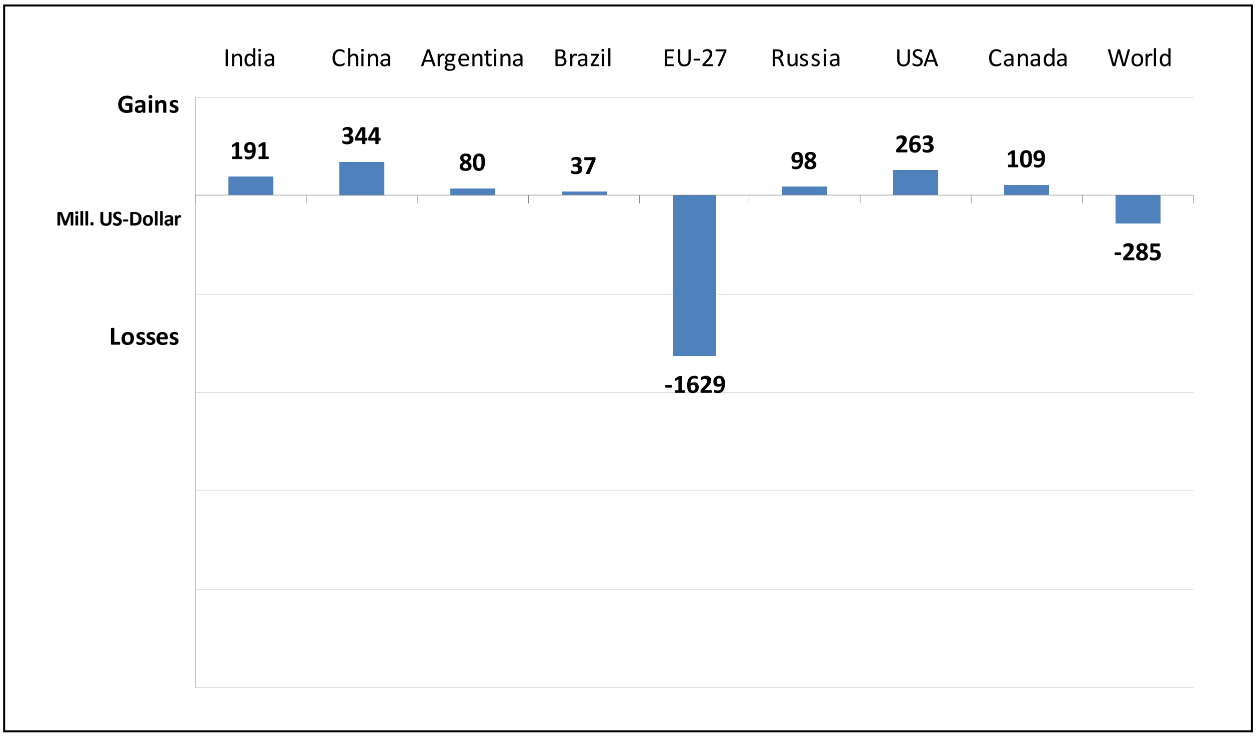
Figure 4.14: Total annual welfare effects of a Glyphosate ban in the EU-27 for selected countries/regions

a) assuming yield depressions of 0%



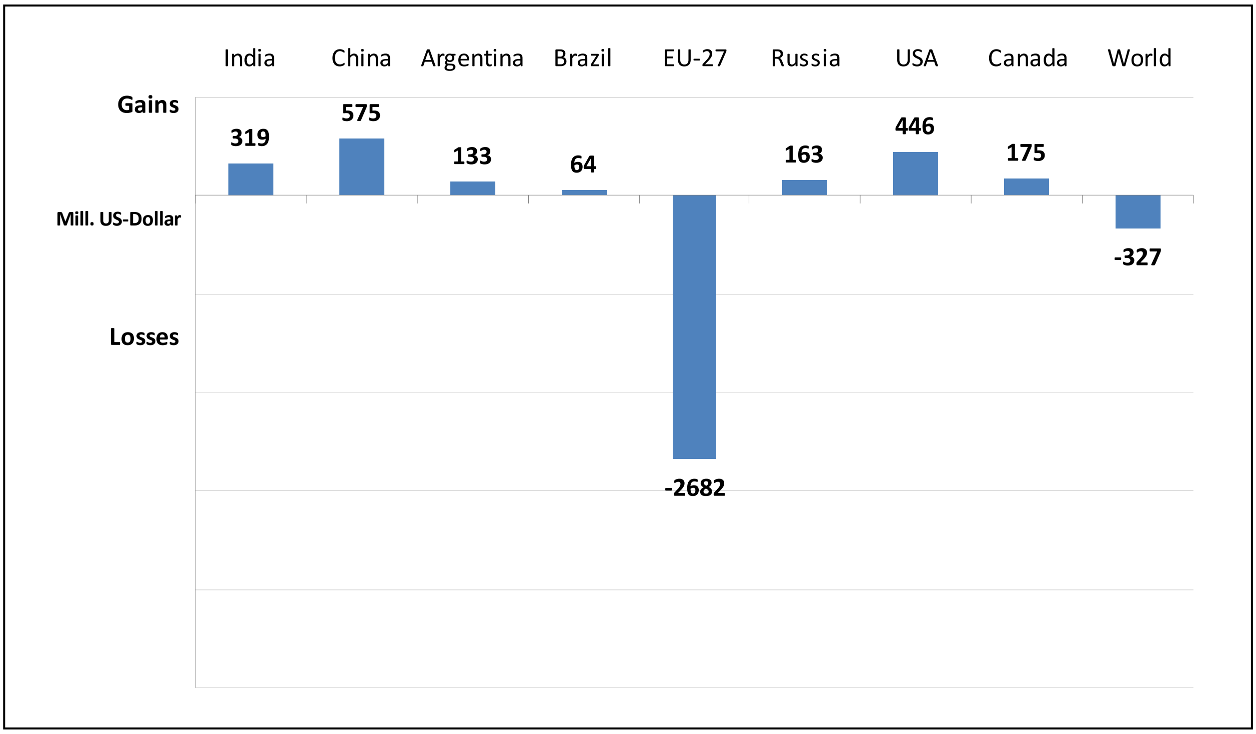
Source: own calculation using AGRISIM, 2011

b) assuming yield depressions of 5%



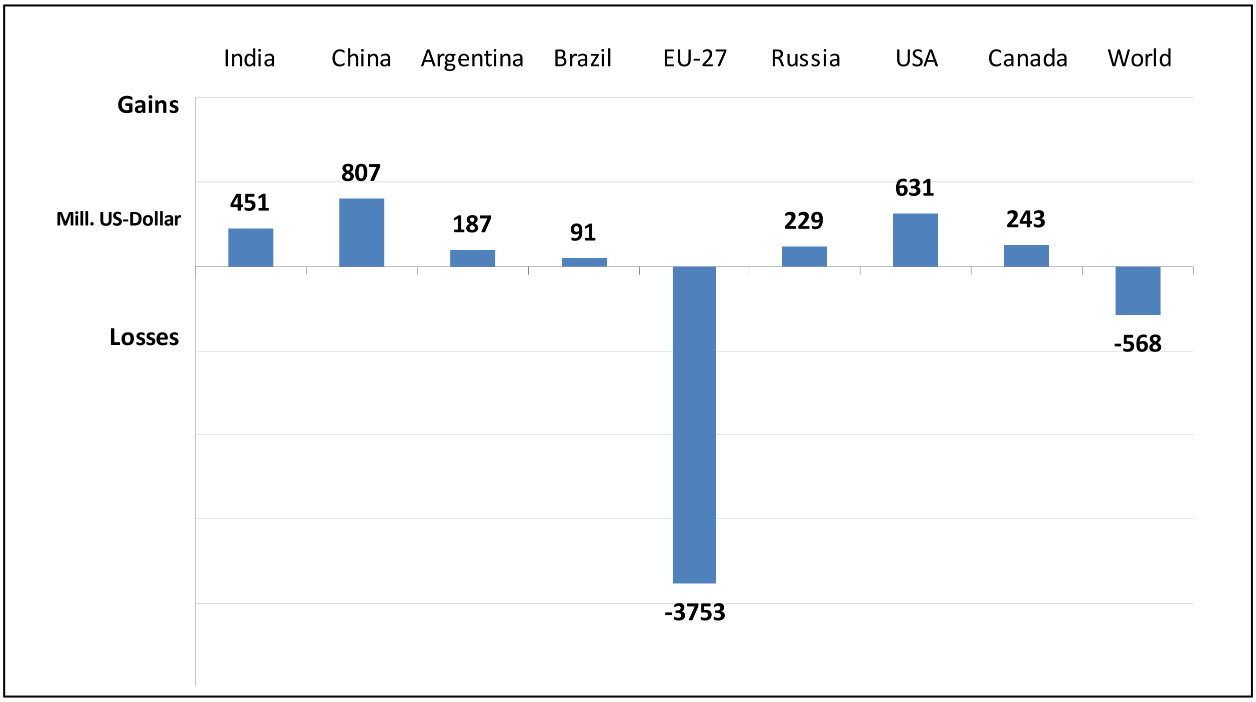
Source: own calculation using AGRISIM, 2011

c) assuming yield depressions of 10%



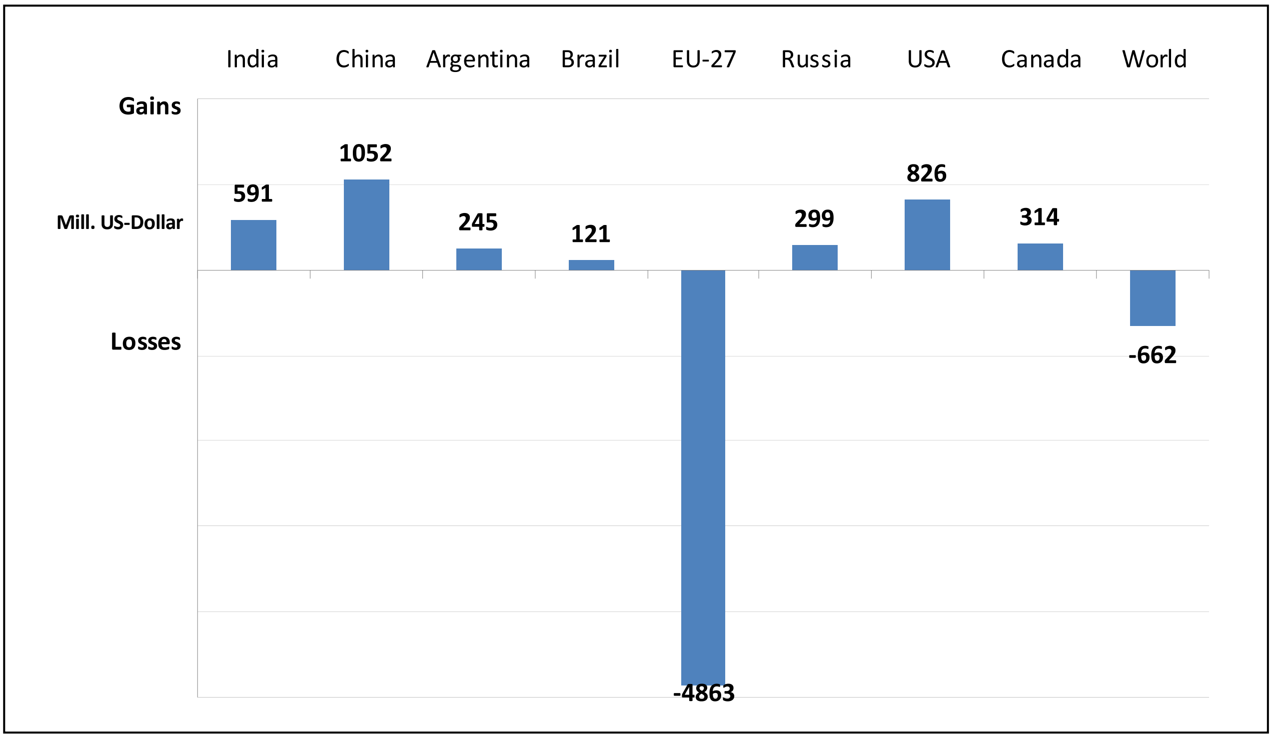
Source: own calculation using AGRISIM, 2011

d) assuming yield depressions of 15%



Source: own calculation using AGRISIM, 2011

e) assuming yield depressions of 20%



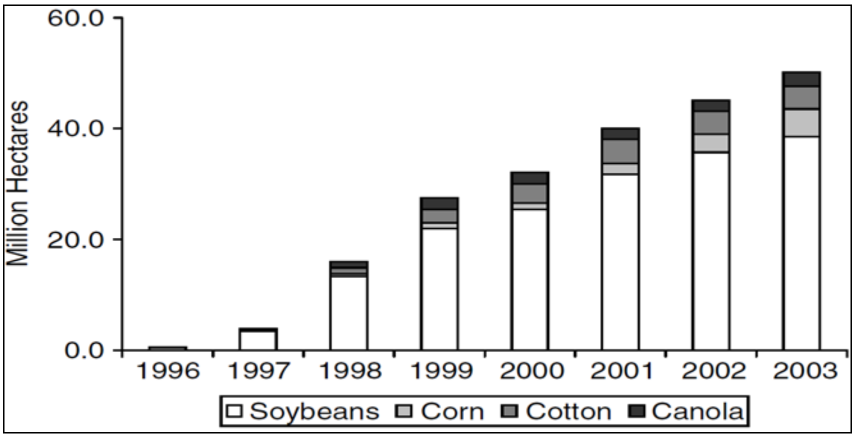
Source: own calculation using AGRISIM, 2011

5 Ecological Relevance

Several studies have emerged assessing the environmental fate and ecological relevance of Glyphosate and its metabolites. Opinions and findings are inconclusive, leaving enough room for further research and analysis. The current deliberations by focusing on a literature survey intend to depict the major research outcomes and present them in a comprehensive way.

With the increase of genetically engineered (transgenics) products and their application to important crops such as soybeans, corn, cotton and canola the usage Glyphosate has increased considerably (Kolpin et al., 2006; Engelhaupt, 2007). Glyphosate as a broad spectrum herbicide that does not harm herbicide resistant transgenics and is easy to apply has been widely adopted since its introduction, which can be derived by looking at the growing global adoption rates for Glyphosate-resistant crops (Figure 5.1).

Figure 5.1: Global adoption rates of Glyphosate-resistant crops



Source: Dill, 2005

Glyphosate has been widely accepted due to its specific advantages like its broad spectrum for the control of weed and its comparatively higher environmental safety than its alternatives (Reddy, 2001; Pline-Srnic, 2005). Nonetheless, Glyphosate in its different formulations has increasingly come under scrutiny, precisely due to its above mentioned advantages. To this background, the ecological relevance of Glyphosate has been discussed in the context of soil, water, plant and biodiversity.

The main concerns that have been raised in connection to that are the herbicide's possible non-target effects, it's persistence in soil and detection in water and the creation of resistant weeds such as horseweed and rigid ryegrass, (Vereecken, 2005; Weaver, 2007).

Numerous studies exist that have analyzed the fate of Glyphosate and its metabolites in soil and their impact on non-target plants. Glyphosate is degraded in soil through microbiological processes that yield the major metabolite AMPA, which is then further degraded to carbon dioxide through microbiological mineralization. Typically Glyphosate shows a high degree of mineralization. Dependent on soil types and their specific characteristics several studies concluded that more than fifty percent of the applied Glyphosate was mineralized after 28-140 days (Accinelli, 2005; Mamy, 2004; Landy, 2005). Generally soil sorption of Glyphosate is very strong, especially to the aluminium and iron oxides components of soils, leaving only little room for soil leaching. Under special conditions, such as the content of the soil organic matter that could block the sorption sites and thus indirectly adversely impact Glyphosate sorption to soil or through an increased pH level content mobility could be increased (Borggaard et al., 2008). To this effect, as the possibility of finding residues in the top soil layers exists, their possible negative effects to conventional, non-resistant cultivars should be taken into account (Laitinen, 2007). A study conducted to assess the bioavailability of Glyphosate found in soil by Stenrod et al. (2004) came to find that only under extremely harsh lab conditions Glyphosate could be extracted from soil through the release of residues, that under normal field conditions would not be bioavailable but bound to soil.

The effect of Glyphosate on soil microflora and microbial processes have also been extensively studied, however yielding contrasting results. A comparatively recent study conducted by Weaver (2007) observed that the impact of Glyphosate on soil microbes and microbial processes was small and inconsistent. Thus the study concluded that the combination of microbial resilience and the lack of soil persistence in the case of Glyphosate would not reduce soil quality (Weaver, 2007).

The soil leaching potential of Glyphosate has been a field of concern, especially related to questions about drinking water and ground water contamination. A review conducted by the European Union of groundwater monitoring studies has based on 36298 samples for Glyphosate and 28254 samples for AMPA come to find only negligible amounts of residues in groundwater (Table 5.1). Less than 1% of the analyzed samples showed Glyphosate and AMPA detects exceeding the EU wide permitted maximum value of 0.1 µg/litre (Horth et al., 2009).

Table 5.1: Ground water monitoring – Glyphosate and AMPA

Water type	Year	Number of sites / samples	Samples where Glyphosate detected		Samples where Glyphosate >0.1 µg l^{-1}	
Substance			**Number**	**%**	**Number**	**%**
Ground water						
Glyphosate	**1993-2009**	**≥8925 / ≥36298**	**≥482**	**~1.3**	**≥270**	**~0.7**
AMPA	**1993-2008**	**≥7678 / ≥28254**	**≥478**	**~1.7**	**≥252**	**~0.9**

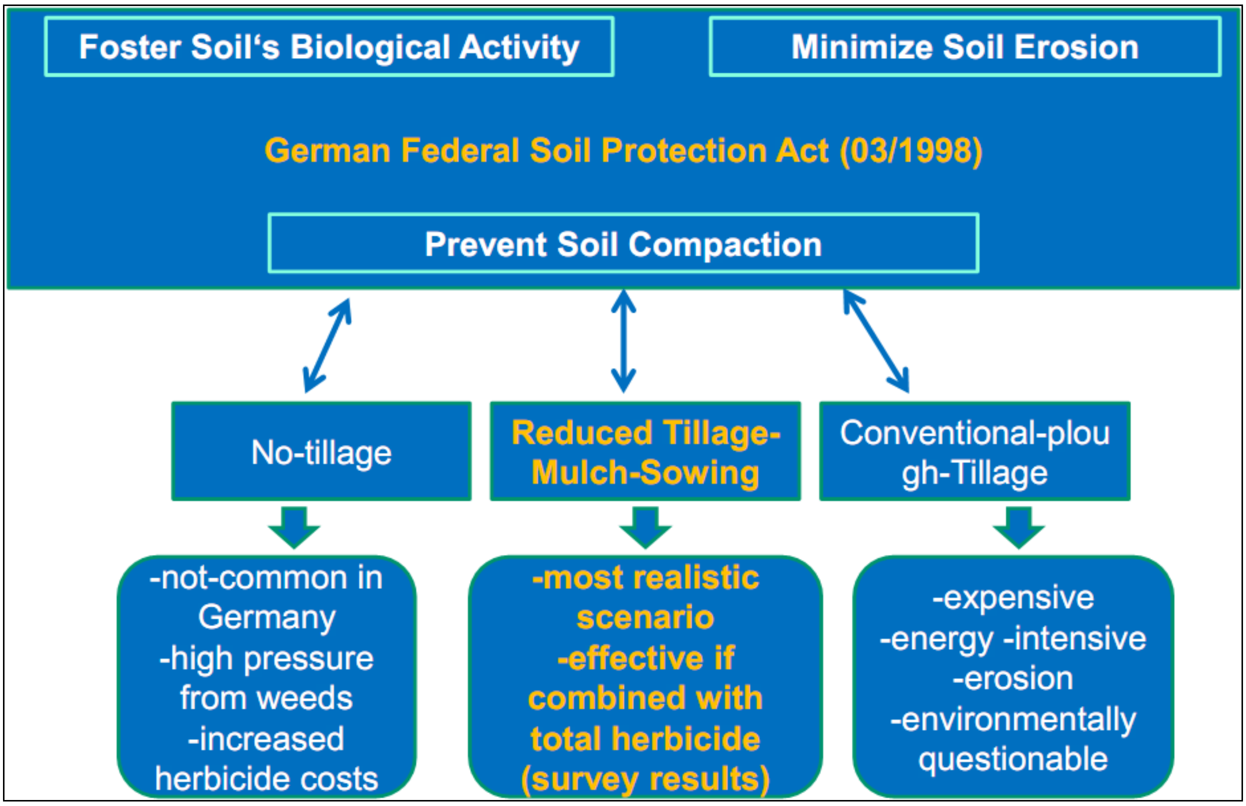
Source: Horth et al., 2009

Other studies conducted by the World Health Organization have identified a low groundwater contamination potential of Glyphosate and its main metabolite AMPA, mainly owing to the strong absorptive properties of Glyphosate. However, the incidence of surface water contamination through soil erosion and the direct aquatic application of the herbicide could not be entirely excluded. Nevertheless, the World Health Organization has identified the trace amounts of Glyphosate and AMPA detected in ground or drinking water as non-hazardous to human health (WHO, 2005). Furthermore, extensive studies conducted for Denmark over a number of years have tested multiple groundwater monitoring sites throughout the country. However, the concentrations in groundwater detected were less than 0.1 µg/litre. In a lysimeter study conducted by Grundmann (2008) Glyphosate leaching in sandy soil was investigated. After three applications of Glyphosate over the period of two years Glyphosate and AMPA were not significantly detected in the leachate, however minute amounts were detected in the soil top layer not exceeding critical values. Stone et al. (2006) tested the fate of Glyphosate in relation to preferential flow conditions caused by extreme wet periods and extreme events such as storms. The results indicated that in soil prone to preferential flow conditions residues of Glyphosate and AMPA might be found in shallow ground water. A review on the fate of Glyphosate and AMPA in drinking water and their removal during the standard water treatment processes came to conclude that chlorine, which is a common disinfectant, can remove Glyphosate and AMPA to a large extent. However, other disinfection methods such as UV, chlorine dioxide or the widely used GAC-Adsorption technique (Granular Activated Carbon) proved quite ineffective for removing Glyphosate and AMPA from raw water (Hall et al., 2007).

Ecological Relevance of Glyphosate in the German context-Study results

In the European context the Federal Republic of Germany is the only member state that has introduced a Soil Protection Act and Ordinance (BBodSchG) in March 1998 and thus legally regulated good farming practices to sustain the country's fertile soils (Figure 5.2).

Figure 5.2: Soil protection under different tillage options in the German context

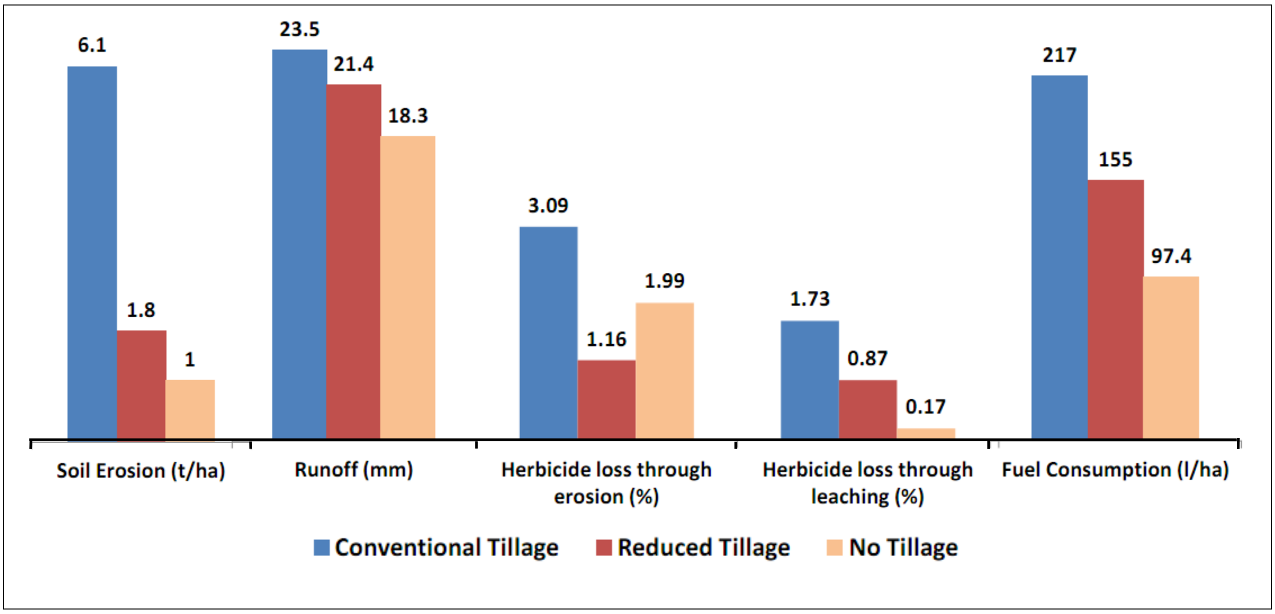


Source: own composition based on survey results, Institute for Agribusiness 2011

To this effect, soil conservation and sustainable farming practices are of paramount importance. The soil conservation act stresses the site-specific and site-adapted treatment of soil, mainly to prevent soil compaction and soil erosion and to foster the soil's biological activity and to sustain its beneficial qualities (BMU, 2006). In this regard different cultivation methods have been discussed which would be most beneficial for the goal of soil conservation and at the same time be realizable. Three methods are available in the German context: conventional cultivation (Ploughing), conservation agriculture (mulch-sowing) and no-tillage practices (Direct-Sowing). Germany strongly emphasizes on conservation agriculture, thus no-tillage only plays a subordinate role. The current study has utilized expert interviews to assess the use of Glyphosate in german agriculture. Against the background of the soil protection act the experts have clearly depicted mulch-sowing as being the best option with its significant advantage over conventional farming that no-plough tillage is practiced and soil fertility is sustained. However, as mulch-sowing (reduced tillage) significantly reduces mechanical tillage, an increased frequency of weed appearance has to be dealt with. This can be achieved through a sustainable application of a broad spectrum selective herbicide (Glyphosate-formulation) in combination with the reduced tillage option before sowing the successive crop. According to the survey results, the practice of mulch-sowing in combination with a total herbicide would help to maintain healthy soil conditions and also improve them by e.g. increasing the soil infiltration capability, thereby reducing the surface run-off and consequently minimizing soil erosion (Figure 5.3). It is widely proven that soil erosion can cause long-term environmental damages, thus being a broad spectrum herbicide, with a strong soil sorption capability and very little mobility, Glyphosate is highly compatible with reduced or no-tillage agriculture (Cedeira et al., 2006).

A major source of expenses and pollution in weed control are the fossil fuels that are used for herbicide application and tillage (Figure 5.3). Every environmental and ecological consideration of the use of Glyphosate has to consider this factor to thoroughly weigh the costs and benefits. Generally, the energy requirement for tillage is higher than for herbicide spraying (Gianessi, 2005).

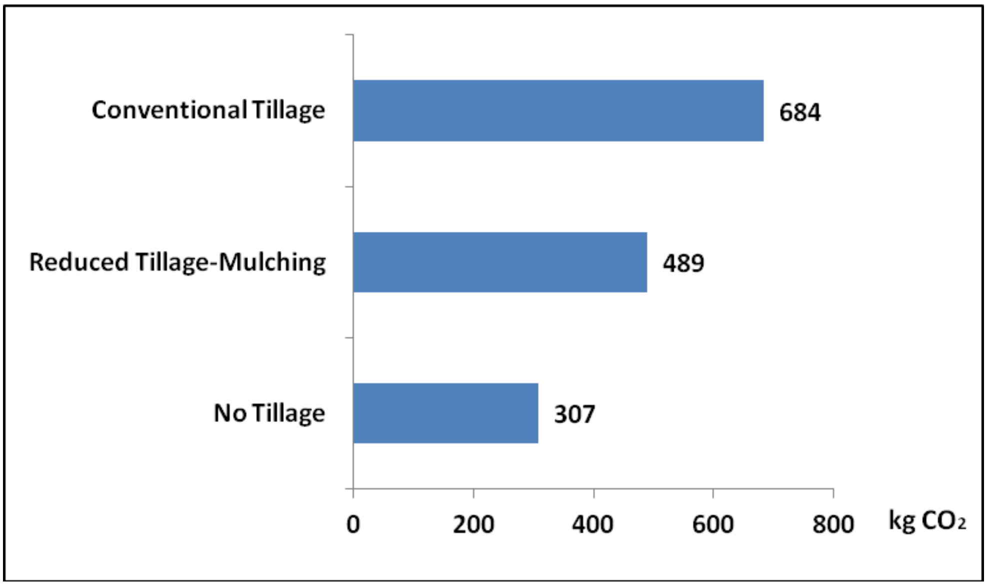
Figure 5.3: Losses through different soil processing methods



** Data has been compiled using Klik et. al (BOKU-'94-'08) and own calculations from expert survey condcucted in 2011. Note: Fuel Consumption Figures have been calculated based on following scenarios: Conventional Tillage = 3 x ploughing ; Reduced Tillage = no plough; No Tillage = direct seed drill; Field size 5 hectares, farm-field-Distance: 2km, Northern-Region*

Conventional plough tillage is an energy intensive procedure and causes high process-related carbon dioxide emissions (Figure 5.4).

Figure 5.4: Investigation of process-related carbon dioxide emissions, Germany*

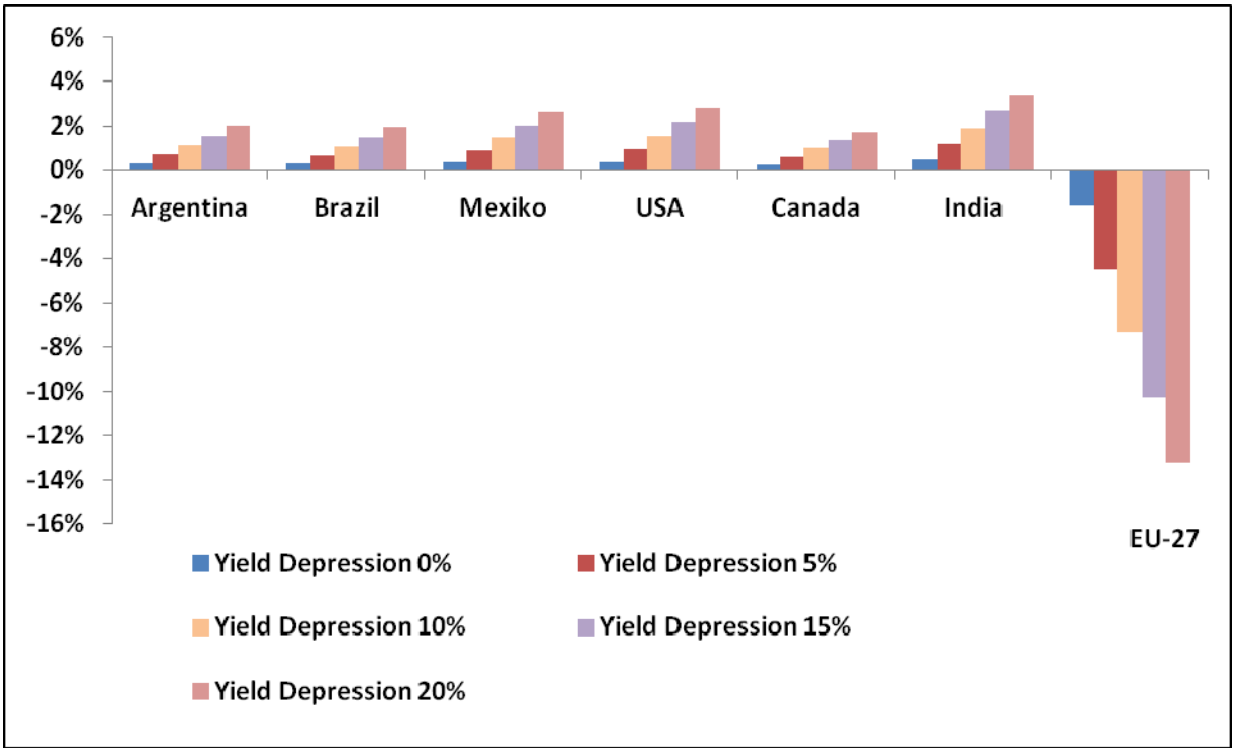


Source: own calculation using data from the expert interviews, Institute for Agribusiness 2011

**Note: Conversion factor: 1 liter of diesel = 3.15 kg CO2; Field size 5 hectares, farm-field-Distance: 2km, Northern-Region*

Furthermore, the calculations using the Multi-Region-Multi-Commodity-Model AGRISIM have been used to further assess the environmental impacts of a Glyphosate ban. For this purpose different yield depression scenarios ranging from 0% to minus 20% have been tested for the case of wheat (Figure 5.5).

Figure 5.5: Change in wheat cultivated area resulting from a Glyphosate ban in the EU- 27 (in %)



Source: own calculation using AGRISIM, 2011

Figure 5.5 clearly depicts the results from a Glyphosate ban in the EU-27. The results of the simulation model AGRISIM indicate that yield depressions in the EU-27 will be most likely compensated through the expansion of the production area or through an intensification of farming, resulting in a significantly increased use of fertilizers and plant protection agents. Especially, as the calculations show, the South American countries (and India) will compensate production losses. In environmentally weak countries, as far as the legislations are concerned, this could result in negative impacts in the long term. Deforestation in South America has been a field of concern for quite some time, thus additional production area, would most probably compete with the existing forest resources, risking the destruction of valuable and most essential carbon sinks to regulate climate change.

A universal solution for the correct tillage system can not be provided because the measures to be applied depend highly on the crop rotation and soil type. Nevertheless, the findings indicate that given Germany’s case, a reduced form tillage (Mulching) in combination with a total herbicide (Glyphosate) seems to be ecologically and economically the most appropriate and realistic solution. Although the environmental and ecological impacts resulting from a Glyphosate ban can be roughly estimated, the overlapping effects in the environmental there can hardly be evaluated in monetary terms. Every step in the handling of pesticides on the farm can present a risk of contamination (transport, storage, handling before-during-after spraying, mixing and loading). Thus as a key to minimize any risks, “good farming practice” is recommended.

6 Conclusions

Key messages from the expert interviews

- In Germany Glyphosate in the framework of the winter cereals and winter rapeseed cultivation is applied on approximately 30% to 35% and 50% of the cultivated areas, respectively.
- Especially for conservation tillage Glyphosate is of great importance and a standardized procedure in most areas.
- As an active substance with a relatively low attached risk of resistance formation, Glyphosate is of great significance for the resistance management in crop farming. A loss of this active substance would entail a considerably faster development of resistances. Particularly, as for the next years no new active substances can be expected.
- A ban on Glyphosate can lead to yield depressions in crop farming.
- In Northern and Southern Germany yield depressions can be compensated through the intensification of crop farming.
- In the coastal regions the presence of resistant weeds can lead to yield depressions in the range between 5% to 10% despite intensification.
- In Eastern Germany due to labor economic reasons crop farming is exercised using mulch-sowing (no-plough tillage).In case of a ban on Glyphosate therefore the stubble treatment/tilth will be intensified and the plough will still be renounced. This will lead to yield depressions of up to 10%.
- Through a Glyphosate ban an entire active substance class will be lost. This would lead to significantly faster resistance formation and higher yield depressions.

Key messages from the agroeconomic calculations

- In case of a Europe-wide yield depression of 5% owing to the regional changes in yields and costs, profit margin changes in Germany in following ranges are revealed:

  -3% to +1.5% in the Region North
  -27% to -4% in the Region East
  -36% to -14% in the Region Coast

- The working costs increase by 5 to 11% for German farms.

Key messages from the sectoral analysis

For European agriculture, in the most realistic scenario (yield depression -5%) of a ban on Glyphosate, reductions of 4.3% to 7.1% in the production of wheat, coarse grains, maize, 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.

- An EU-ban on Glyphosate reduces the EU-Production of wheat, coarse grain, maize, oilseeds and sugar by 4.3% to 7.1% assuming an overall yield depression of 5% and corresponding adjustments of variable costs as well as by 13.3% to 16.8% assuming the worst case of a 20% yield depression, while all other producers on world markets increase both their production volumes and shares.
- The EU-net-trade of the five commodities in contrast would be much more affected by a ban on Glyphosate in terms of absolute volumes and trade shares. The EU changes the trade status from a net-exporter to a net-importer for wheat and coarse grains and significantly increases (decreases) the import deficit (export surplus) for oilseeds and maize (sugar).
- The total annual EU-welfare loss in case of a ban on Glyphosate comes up to 1.4 billion US-Dollar in case of an overall yield depression of 5% and to 4.2 billion US-Dollar in case of yield depression of 20% where the burden is mainly born by producers. But also consumers and taxpayers are negatively affected because most food prices are increasing and the loss of import taxes outweigh the savings in export subsidies.
- Net-import developing countries and consumers are negatively affected by world market price increases of 0.04% to 6.42% and total welfare losses whereas most emerging and industrialized countries benefit from the EU-ban on Glyphosate.

- Finally more land is necessary to meet the food requirements of a growing world population.

Key messages from the ecological relevance

- A patent solution for the correct tillage system can not be provided because the measures to be applied depend highly on the crop rotation and soil type. Nevertheless, the findings indicate that given Germany's case, a reduced form tillage (Mulching) in combination with a total herbicide (Glyphosate) seems to be ecologically and economically the most appropriate and realistic solution.
- Every step in the handling of pesticides on the farm can present a risk of contamination (transport, storage, handling before-during-after spraying, mixing and loading). Thus as a key to minimize any risks, "good farming practice" is recommended.

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