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The economic relevance of glyphosate in Germany

Study

Germany, July 2017

Authors:

Bob Fairclough, PhD, Kleffmann Group

Puran Mal, PhD, Kleffmann Group

Stefan Kersting, PhD, Kleffmann Group

Edited by:

Stefan Kersting, PhD, Kleffmann Group

Executive Summary

Glyphosate, which is the active substance in numerous broad-spectrum herbicides, is currently under review in the European Union within the regulatory framework foreseen within the renewal authorization for active substance. The approval of active substances by the EU Commission is a prerequisite for the authorization of plant protection products at the national level. With the participation of all member states, two EU agencies have conducted a risk assessment of glyphosate. Both EFSA and ECHA concluded that glyphosate was safe when used properly and in accordance with its intended use, and cannot be classified as carcinogenic.

The present study examines the economic importance of glyphosate for German agriculture on a single farm level.

Specifically, this study analyses the economic impact that a glyphosate ban would have on agriculture in Germany. The study focuses on the effect on farms' contribution margin (per hectare) when they produce one of the major crops (wheat, barley, oilseed rape, silage maize, sugar beet, apples or vine) without glyphosate being available for weed control.

The results show that the largest absolute loss in contribution margin would occur in viniculture (losses of up to 220 €/ha) and apple farming (losses of up to 186 €/ha). This may be explained by the fact that cultivation of such permanent crops is labour-intensive, requiring a lot of additional labour input in the absence of glyphosate. Since the overall contribution margin of these crops is, however, quite high the relative impact to the overall profitability is only of marginal significance.

The crops that would be mostly affected by a glyphosate ban are barley and silage maize. Their contribution margin would shrink by 40 to 70% and might even become negative when farmers also suffer yield losses. This could have far-reaching impacts on agriculture industry's structure: where the cultivation of certain crops is no longer profitable, their production would either need to be subsidized, or farmers would need to switch to the cultivation of other crops.

During expert interviews, it has been underlined that a glyphosate ban would raise the necessity of traditional soil cultivation (i.e. tillage). Increasing prevalence of conventional tillage would lead to higher diesel consumption, which would in turn result in higher CO_2 emissions. Moreover, the rising number of passage over the fields with heavy machinery can damage the soil structure and favour soil erosion, which might eventually lead to further yield losses. In the absence of plant protection products containing glyphosate, contribution margins would decrease further due to a higher demand of labour.

Overall, the combined impact of economic and ecological effects indicate that in many cases sustainable agriculture is under threat in parts of Germany in the absence of glyphosate.

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Introduction

Ever since the active substance glyphosate was launched on the market around 40 years ago, it has become the most prevalent agro-chemical substance worldwide. With an area of 400 million hectares treated worldwide, it is one of the most extensively used active ingredients. Countless farmers and growers benefit from the convienient handling and broad spectrum of effects that glyphosate offers concerning weed control. In addition, only few alternative substances exist that are as efficient as glyphosate. Effective weed control is essential in agriculture in order to obtain high yields, which ultimately secure the long-term food consumption needs of a growing world population.

Glyphosate has been thoroughly tested to ensure that it is non-hazardous to the environment and other organisms. However, after a long history as an environmentally friendly active ingredient, it has increasingly become the focus of European regulatory authorities in the last few years. This development is mainly due to a study conducted by the International Agency for Cancer Research (IARC), which concluded that the active substance glyphosate is “probably carcinogenic.” This is contrary to the European Chemicals Agency’s (ECHA) study, which classifies glyphosate as non-carcinogenic and maintains the existing classification as "safe for health."

Despite this assessment, the European Commission has not yet decided whether glyphosate will continue to be authorized in the EU in accordance with Annex 1. Such a decision would guarantee that farmers and crop growers in Germany can continue to use the active ingredient glyphosate over the next few years.

The aim of this study is to highlight the importance of the active substance glyphosate for German agriculture. We are primarily interested in the economic impact that a possible non-renewal of glyphosate would have on agriculture. The focus here is less on the overall economic implications, and more on the consequences for the individual farmer. Agricultural businesses’ profitability, which ultimately also reflects the economic impact of a glyphosate ban, is measured by contribution margin per hectare. Therefore, this study examines how the contribution margin per hectare changes if farmers forgo glyphosate in the cultivation of crops, whereby different crops (winter wheat, winter barley, oilseed rape, silage maize, sugar beets, apples and vine) are taken into consideration. In the absence of glyphosate, farms can combat weeds either with other herbicides or mechanically, which not only leads to higher production costs, but also fosters soil erosion and leads to an increase in CO_2 emissions.

1. Chapter 1 – Agriculture in Germany

1.1. Farm structures

In order to better assess the economic importance of glyphosate for agriculture in Germany, it is necessary to have an idea of the structure and development of agricultural production in Germany. Similar to many other industrialized countries, there is a fundamental structural change currently in agriculture in Germany. On the one hand, the number of manufacturing establishments is decreasing, while the average operating size is steadily increasing. Table 1 provides an example of how the number of farms producing crops has developed over the last ten years.

It is evident that the number of manufacturing businesses has decreased by at least 10% between 2005 and 2013 in all production sectors. Potato and fruit growers, in particular, have declined, where only 53% and 64% of farms are still in business compared to 2005.

Table 1: Number of farms in Germany per main crops

Crops	2005	2007	2010	2013
Wheat	173,840	163,270	147,350	138,530
Barley	180,110	167,200	134,490	123,280
Silage maize	40,980	35,470	35,130	37,160
Oilseed rape	74,730	77,160	63,280	56,750
Sugar beets	40,890	37,770	30,690	29,570
Potatoes	63,920	55,420	39,950	33,760
Vegetables	18,680	17,080	14,330	13,310
Vine	27,290	25,550	20,290	18,650
Fruit	20,760	19,180	16,950	13,280

Source: EUROSTAT

1.2. Agricultural area (2011-2016)

The size of the total agricultural area in Germany has only seen minimal changes in recent years and remains relatively constant at around 16.7 million hectares. As can be seen in Table 2, arable production is dominanted by field crops, such as cereals, corn and oilseed rape, which account for more than 60% of agricultural land and about 90% of arable land. The size of these crop cultivation areas has only changed slightly between the years 2011 and 2016. Although corn cultivation has been particularly influenced by the Renewable Energy Act (Erneuerbares Energiengesetz, EEG), this is true for silage maize, as well. However, the proportion of silage maize has grown consistently, whereas the areas where grain corn (including CCM) is cultivated have declined.

Other field crops cultivated in Germany include potatoes, vegetables and sugar beets. Compared to cereals, corn and oilseed rape, their cultivation area is much smaller. The size of the cultivation area has declined significantly over the last few years (-16% between 2011 and 2016), particularly with regards to sugar beets, the cause of which may lie in the phasing-out of the sugar quota as of September 30, 2017. In addition to the field crops referred to above, Germany has other important permanent crops, of which vine and apple certainly play the most important role.

Table 2: Development of agricultural area (in 1,000 hectares) in Germany (2011 to 2016)

Crop	Sub-group	2011	2012	2013	2014	2015	2016
Agricultural area	**total**	**16,721.30**	**16,667.30**	**16,699.60**	**16,724.80**	**16,730.70**	**--**
From that							
Cereals	In total	6,500.60	6,527.30	6,533.70	6,468.60	6,529.20	6,325.00
	Wheat	3,248.20	3,056.70	3,128.20	3,219.70	3,282.70	3,201.70
	Barley	1,598.10	1,677.80	1,570.40	1,573.70	1,621.80	1,605.00
Silage maize		2,516.70	2,564.20	2,500.20	2,573.90	2,555.90	2,553.90
Oilseed rape		1,328.60	1,306.20	1,465.60	1,394.20	1,285.50	1,325.70
Sugar beets		398.10	402.10	357.40	372.50	312.80	334.50
Potatoes		258.70	238.30	242.80	244.80	236.70	242.50
Vegetables		122.09	126.46	124.64	126.61	125.61	131.68
Vine		99.75	99.58	99.49	100.08	99.91	100.04
Apples		31.76	31.74	31.74	31.74	31.74	31.74

Source: EUROSTAT

1.3. Agricultural production (2011-2016)

Table 3 provides an overview of the absolute quantities harvested in Germany in recent years. In addition to the agricultural area, the average production volume is of essence, since it can differ significantly depending on the crops (see Table 4). With the exception of silage maize, sugar beets, potatoes and apples have the largest yield potential per hectare, which is why the absolute production volume of these crops is also comparatively high. Nevertheless, cereals still constitute the largest production volume, which is due to the fact that grain products are mainly used as cattle feed.

Table 3: Main crop production volume (in 1,000 tons) in Germany (2011 to 2016)

Crop	Sub-group	2011	2012	2013	2014	2015	2016
Cereals	total	41,960.40	45,441.00	47,793.20	52,048.20	48,917.70	45,401.00
	Wheat	22,782.70	22,409.30	25,019.10	27,784.80	26,549.50	24,463.80
	Barley	8,733.80	10,391.30	10,343.60	11,562.80	11,629.90	10,730.50
Corn (CCM)		5,183.60	5,514.70	4,387.30	5,142.10	3,973.00	4,017.80
Oilseed rape		3,869.50	4,821.10	5.784,30	6,247.40	5,016.80	4,579.60
Sugar beets		29,577.50	27,686.80	22,828.70	29,748.10	22,572.00	25,497.20
Potatoes		11,837.20	10,665.60	9,669.70	11,607.30	10,370.20	10,772.10
Vegetables		154.60	138.80	129.50	155.30	276.80	290.20
Vine		1,251.08	1,227.18	1,139.48	1,244.82	1,199.03	1,225.57
Apples		898.45	972.41	803.78	1,115.90	973.46	1,032.91

Source: EUROSTAT

The harvested quantities show that crop production is very volatile and subject to strong annual fluctuations. Changes of up to 30% in comparison with the harvested quantities in the previous year are not rare. This can mainly be attributed to diverging weather conditions, which have a significant impact on the yields, even though cultivation conditions and other production factors play an important role, as well.

Table 4: Main crops' average output (in tons/hectare) in Germany (2011 to 2016)

Crop	Sub-group	2011	2012	2013	2014	2015	2016
Cereals	total	6.46	6.97	7.32	8.05	7.49	7.18
	Wheat	7.01	7.33	8.00	8.63	8.09	7.64
	Barley	5.47	6.19	6.59	7.35	7.17	6.69
Corn (CCM)		10.72	10.55	8.91	10.76	8.88	9.65
Oilseed rape		2.91	3.69	3.95	4.48	3.90	3.45
Sugar beets		74.30	68.85	63.88	79.86	72.17	76.23
Potatoes		45.76	44.75	39.83	47.42	43.81	44.42
Vegetables		2.77	3.10	3.41	3.72	3.50	3.31
Vine		12.54	12.32	11.45	12.44	12.00	12.25
Apples		28.29	30.64	25.32	35.16	30.67	32.54

Source: EUROSTAT

1.4. Development of producer prices (2011-2015)

Absolute production volume also affects the prices that German farmers receive in exchange for their goods. Higher yields generally lead to increased supply, which, in turn, has a negative impact on producer prices. However, it should be noted that not only the production volume is relevant in Germany, but the production quantity in Europe and worldwide also plays an important role. This is particularly relevant with respect to crops such as cereals, corn, and oilseed rape. Table 5 shows how producer prices have developed on average in Germany from 2011 to 2015.

Although market speculation always influences producer prices, which are subject to short-term fluctuation, the price level of cereals and corn has clearly declined in recent years (decline of up to 28% between 2012 and 2015). A similar decline in the price level can also be observed with regards to sugar beets, despite the fact that sugar quotas play a role, as well. Producer prices directly affect farmers' contribution margins and will therefore be important in the course of this study when identifying the economic impact of glyphosate.

Table 5: Average producer prices (in EUR/ton) from 2011 to 2015

Crop	2011	2012	2013	2014	2015
Wheat	215.0	220.0	20.0	169.5	159.6
Barley	187.0	209.8	18.6	157.3	149.6
Silage maize	210.0	210.7	203.3	159.3	162.4
Oilseed rape	376.0	402.1	402.1	402.1	349.6
Sugar beets	26.0	45.1	50.1	48.8	33.6
Potatoes	136.0	114.0	114.0	136.3	128.6
Vine	-	132.9	156.0	158.8	149.2
Apples	404.0	388.2	512.6	490.8	295.0

Source: EUROSTAT

1.5. Total value of agricultural production (2011-2015)

A crop's overall economic importance can be assessed when multiplying its total production quantity with the average producer price. As shown in Table 6, wheat has the highest production value in Germany, followed by vegetables and oilseed rape. High producer prices mainly account for vegetables' high production value, which is indicated by the fact that the quantity produced is much lower compared to those of other crops (see Table 3). The production value for wheat and vegetables is at a consistently high level, while the value for sugar beets, potatoes and apples, for instance, fluctuates more significantly. Annual changes amount to surpluses of up to 60% and 52%, as well as diminuations as low as 49%.

Grain maize and vine can be considered an exception since their production value has developed with relative continuity. While the value of vine rose by almost 20% between 2011 and 2015, the production value of grain maize decreased by more than 60% over the same period. The latter has to do with falling prices for grain maize, as well as with increasingly processed silage maize.

Table 6: Agriculture production value (in million euros, producer prices) 2011 to 2015

Crop	2011	2012	2013	2014	2015
Wheat	4,100.00	4,657.00	4,807.00	4,621.08	4,104.52
Barley	1,587.00	2,075.00	1,896.00	1,773.81	1,690.18
Grain maize	1,034.00	1,136.00	858.00	803.45	632.42
Oilseed rape	1,693.00	2,185.00	2,310.00	2,463.42	2,138.36
Sugar beets	783.00	1,263.00	1,157.00	1,533.59	758.42
Potatoes	1,893.00	1,081.00	1,071.00	1,011.35	1,539.32
Vegetables	2,079.00	2,168.00	2,400.00	2,219.13	2,495.69
Vine	1,114.00	1,207.00	1,315.00	1,462.84	1,323.61
Apples	359.00	376.00	411.00	528.20	266.36

Source: EUROSTAT

2. Chapter 2 – Glyphosate

2.1. The provenance of glyphosate

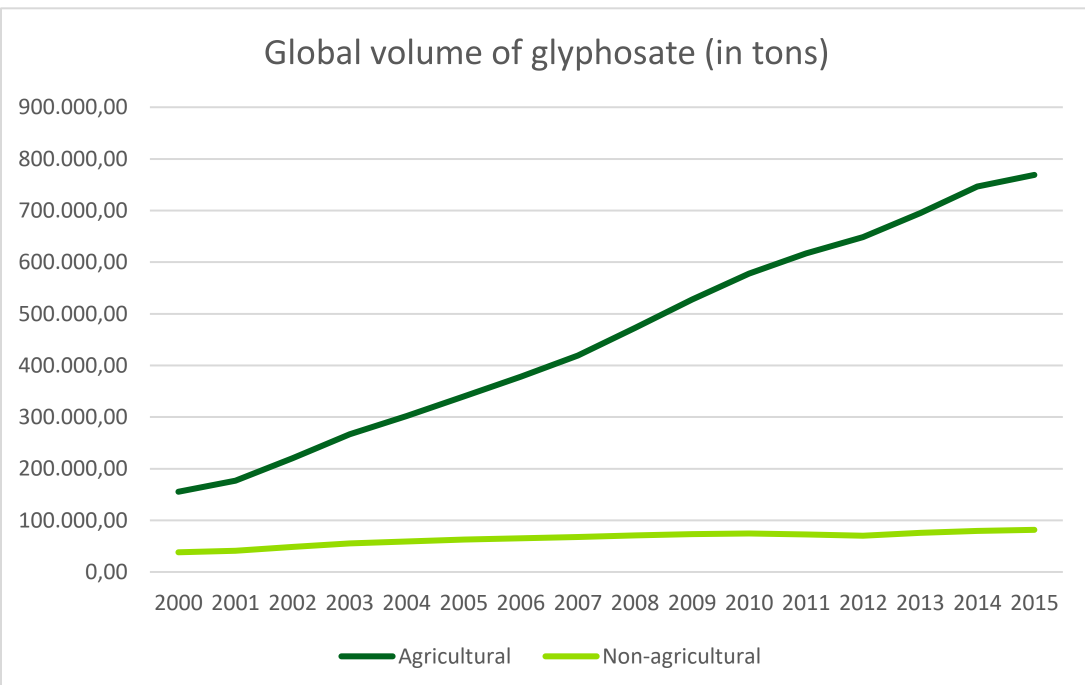
The chemical molecule, now known as glyphosate, was originally discovered in 1950 by Swiss chemist Henri Martin while working for the pharmaceutical company Cilag. Since the substance did not provide the company with any benefits in the pharamceutical industry, it was not developed further at this stage. It was only in the early 1970s that the potential of glyphosate as a weed-killer was identified. At the time, Monsanto tested the ability to soften water in different molecules under the direction of Dr. John Franz. Almost by chance, he discovered that two chemical substances, similiar to glyphosate, had a promising effect on perennial weeds. Subsequently, Monsanto began to produce artificial derivatives of these substances, which would later become the most important pesticide in the world.

2.2. Becoming the most succesful plant protection substance worldwide

One of the first patents pending on the active ingredient glyphosate was U.S. Patent No. 3,799,758, issued on March 26, 1974. Registered under the trademark name "Roundup®," the product was first used commercially on Malaysian rubber plants and British wheat fields. Originally designed to combat sprouting weeds on stubble fields, it was later used for siccation before harvesting as well.

Over time glyphosate has not only developed to become the most widely used herbicide worldwide, but has also had a profound impact on agricultural production by promoting ploughless soil cultivation and by sustainably changing the agricultural industry in combination with the cultivation of genetically modified crops. For these reasons, worldwide sales figures have increased over the last few years (see Fig. 1).

Fig. 1: Quantity of glyphosate applied worldwide



Source: USDA, Agriglobe.

The amount of glyphosate used in agriculture clearly exceeds the amount used for non-agricultural purposes (i.e. in the railway network, home and garden). In 2015, for instance, 850,000 tons of glyphosate were applied worldwide on a total area of 400 million hectares (see Table 7), 360 million of which are farmland.

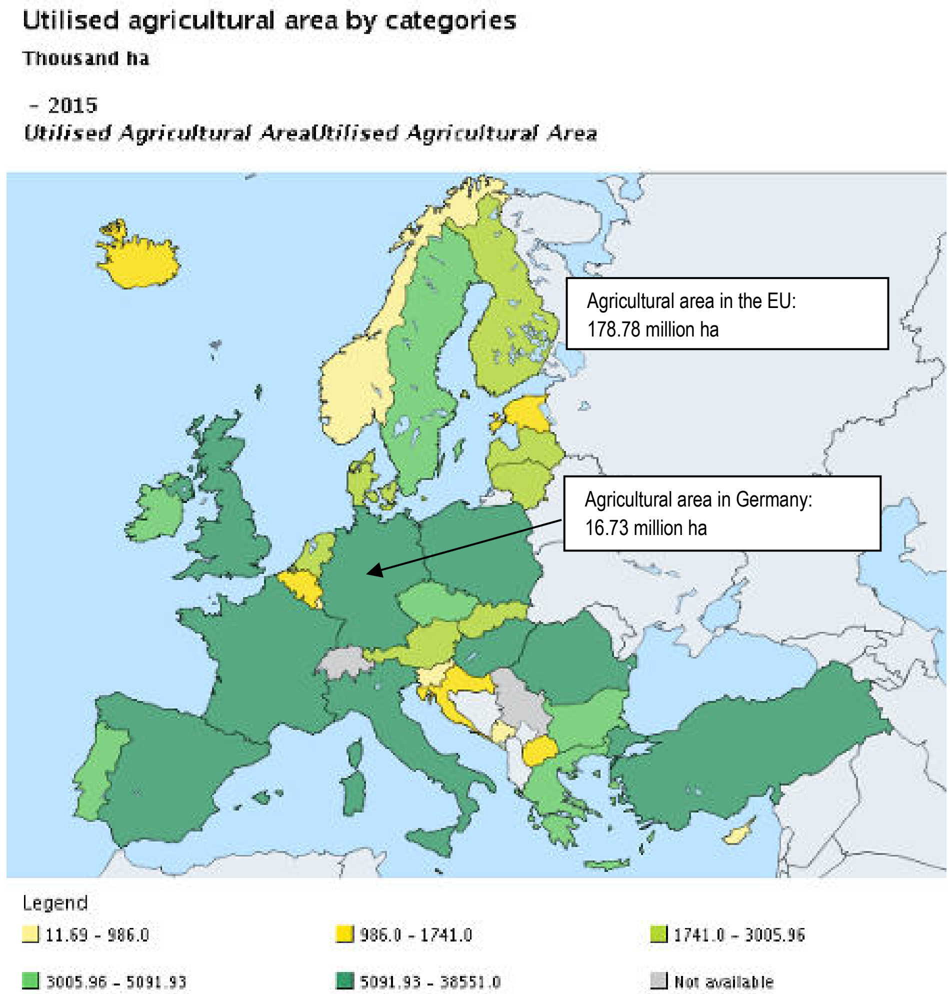
Table 7: Amount of glyphosate used worldwide

Glyphosate: Figures and Facts (2015)	
Number 1 substance with a sales volume of **US$ 6 billion** worldwide[1]	
Amount of glyphosate applied worldwide: **850,577 tons** - agricultural use 768,997 tons, *that is* 90% - Non-agricultural use 81,600 tons, *that is* 10%	
Average dosage	agricultural: 2.13 kg/ha non-agricultural: 1.94 kg/ha
Treated area	agricultural: 361 mil. ha non-agricultural: 42 mil. ha

In order to grasp the scale of these figures, it is useful to know that the total area of agricultural land within the European Union (EU 28) amounts to 178 million hectares, which corresponds to half the area treated with glyphosate worldwide.

[1] Glyphosate is the number 1 substance not only with regards to sales volumes, but with respect to the application surface and the application quantity as well.

Fig. 2: Agricultural area in the EU (178 million ha) – 2015

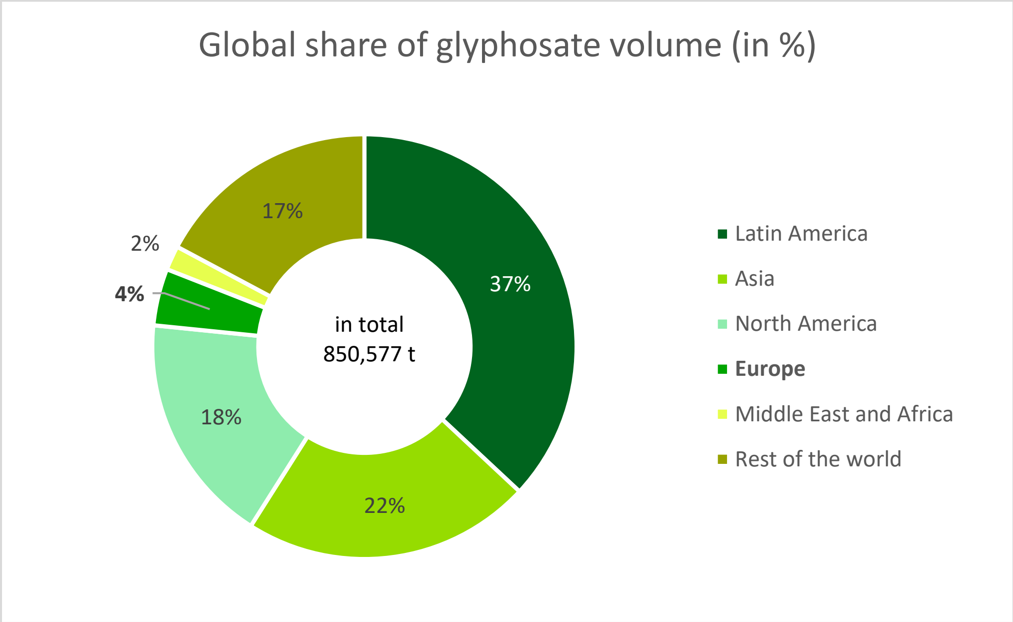


Source: Eurostat; the agricultural area corresponds to the cultivated area. This includes the following categories: farmland, permanent grassland, permanent crops, home gardens and kitchen gardens.

2.3. Application of glyphosate worldwide

After Monsanto first patented the active ingredient glyphosate, more than 40 companies worldwide today marketed it after the patent protection expired. Glyphosate is authorized to be marketed across the EU and is included as an active ingredient in over 2,000 registered pesticides. However, sales volumes in Europe only make up a very small part of total sales (see Fig. 3).

Fig. 3: Amount of glyphosate used worldwide per region (in 2015)



This can be explained by the fact that glyphosate-containing pesticides have been particularly successful when combined with the cultivation of genetically modified crops. The cultivation of so-called GMOs is considered a central element of modern agriculture in most parts of the world and plays a particularly important role in the USA, Canada, and Brazil. Thus, more than half of the amount of glyphosate worldwide is used in North and South America.

2.4. Glyphosate in Europe

Although on a global scale the quantity applied in Europe is relatively small, glyphosate can still be considered an important component of plant protection. Glyphosate has become one of the most popular herbicides in Europe thanks to its broad range of effects and flexible handling.

While consumption is high in southern European countries, such as Spain or Italy, Germany's share, which merely accounts for 5%, is rather low (see Fig. 4). This is mainly due to the fact that glyphosate is predominantly used in fruit and vegetable cultivation, which is largely concentrated in southern Europe (see Fig. 5). In Germany, more than half of the amount of glyphosate is used for treatment of cereal fields. This is largely explained by the fact that, relatively speaking, Germany grows large amounts of cereals, which cover 6.53 million hectares (about 40% of the agricultural area in 2015).

Therefore, the absolute figures as such are not directly conclusive when assessing the importance of glyphosate for the production of a particular crop in Germany and the economic consequences that would result from a ban. As Fig. 7 illustrates, fruit and vine growers are particularly dependent on glyphosate, with over 75% of them currently using glyphosate. Furthermore, when considering the amount of herbicides being used in total, the share of glyphosate is very high in this case with 41% and 61% of fruit and vine growers, respectively, relying on glyphosate when treating their plants. Consequently, it can be assumed that a glyphosate ban would highly affect fruit and vine growers' contribution margins.

Fig. 4: Amount used in Europe (in 2015)

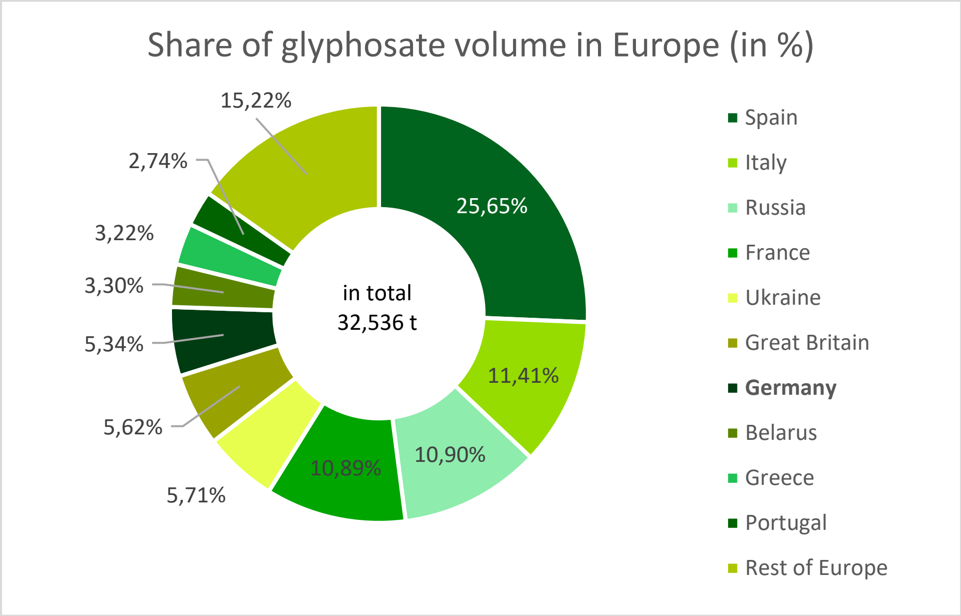


Fig. 5: Amount used per crop in Europe (in 2015)

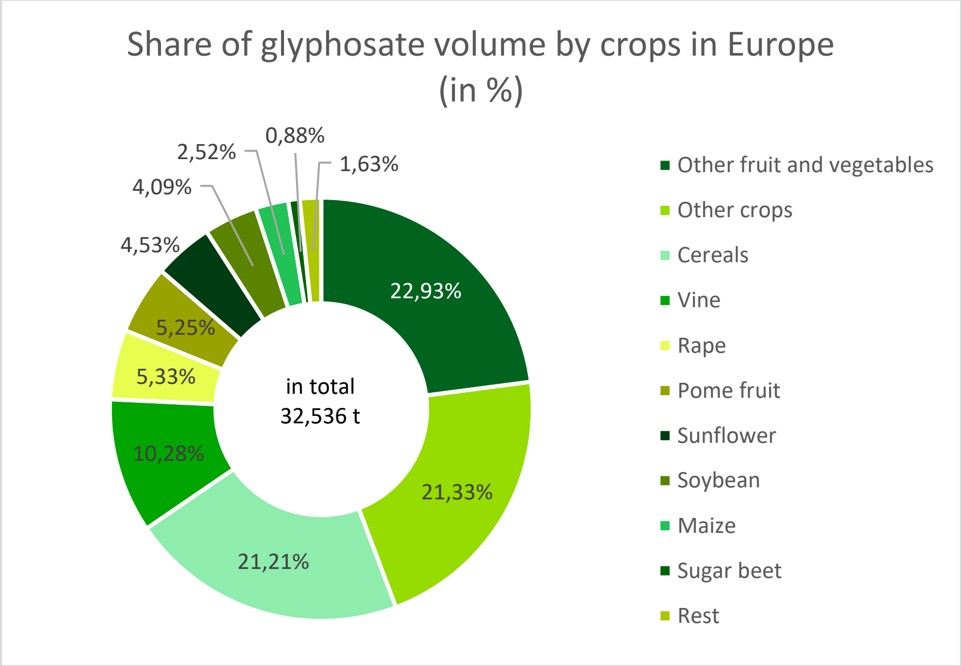


Fig. 6: Amount used per crop in Germany (in 2015)

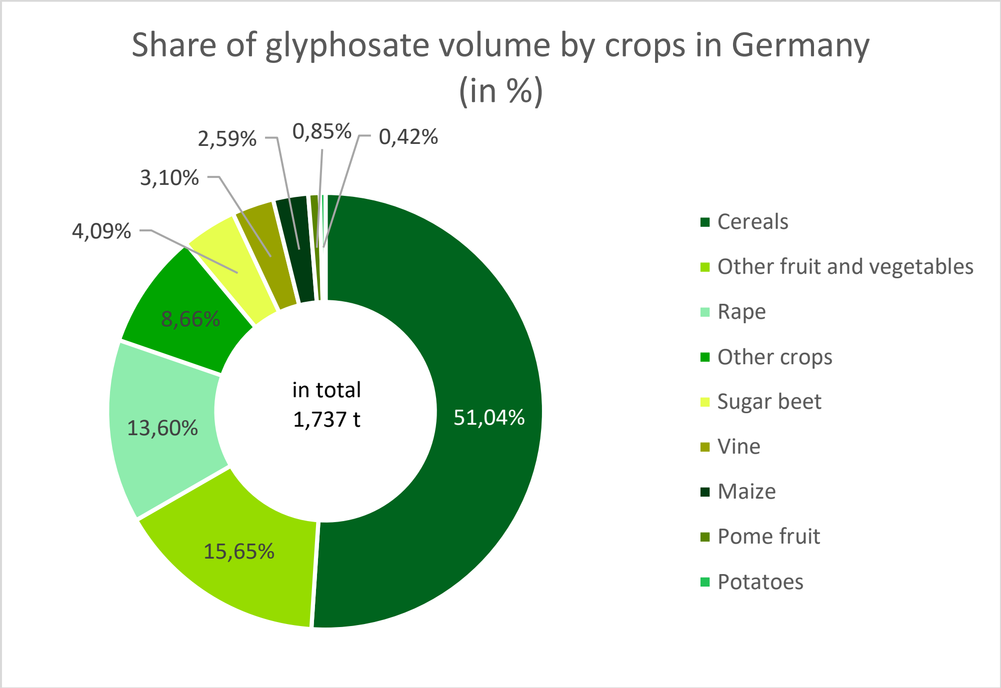
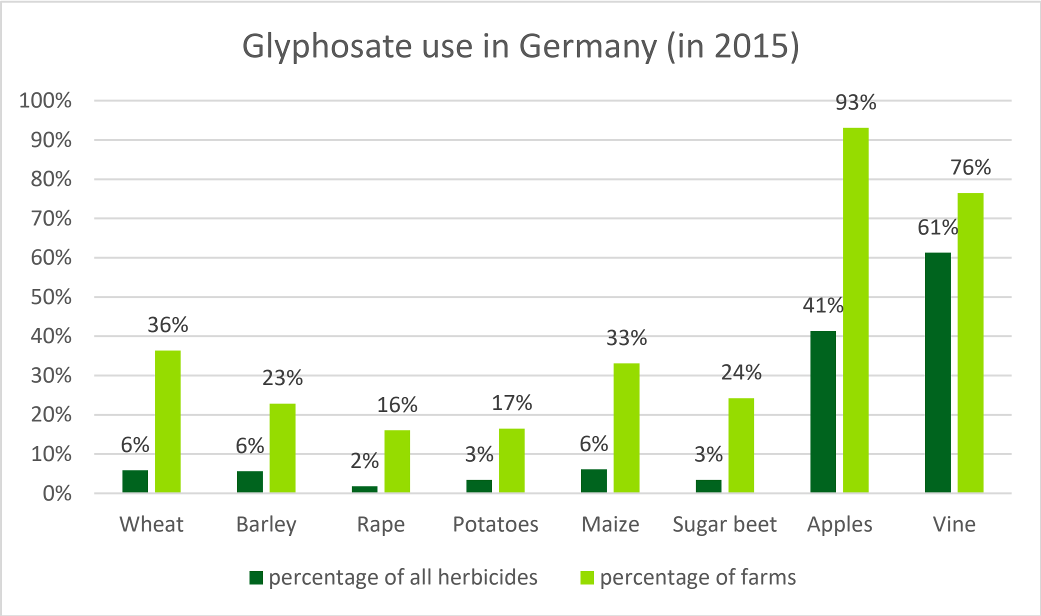


Fig. 7: Importance of glyphosate for the production of different crops in Germany (in 2015)



3. Chapter 3 – Background information on the economic study

3.1. Aim and scope of this study

Regulatory pressure within the EU, as well as the trend of regulatory and legislative decisions being increasingly influenced by public opinion rather than informed scientific rigor, make it necessary to evaluate the benefits of glyphosate from the farmers' point of view. This is especially true since glyphosate is a substance that is essential for European agriculture, in particular, to combat persistent weeds. If weeds can no longer be controlled effectively, this may lead to higher production costs and/or losses in farmers' harvests, which negatively affects farmers' incomes. Farmers who cannot produce a certain type of crop in a cost-effective manner without using glyphosate will cease production in the long term, which can in turn have a significant impact on the entire agricultural sector.

This economic analysis focuses on the effects that a possible glyphosate ban could have on an individual, representative agricultural business. The contribution margin per hectare, which is the difference between revenue and variable costs per hectare, is used as an indicator. The economic impact of a glyphosate ban can be estimated when observing the difference between the contribution margin when using glyphosate and in the case of a glyphosate ban. Scenarios that can occur in the case of a ban on glyphosate and can affect the contribution margin include *inter alia*:

- Loss in harvest yields,
- A decline in quality of yields,
- Rise in production costs,
- Decline in average income,
- Costs for waste disposal of an active ingredient.

Since a glyphosate ban would affect the production of various crops to different extents, the contribution margin will be determined individually for the most important crops grown in Germany. These include winter wheat, winter barley, oilseed rape, silage maize, sugar beets, apples and vine. In addition, the following will be assumed:

1. All calculations and projections are based on certain assumptions regarding microeconomic conditions, political framework conditions, weather conditions and international developments.
2. This analysis is based on the market conditions present in the year 2016.
3. This analysis is based on a ceteris paribus assumption.
4. The economic assessments are based on the parameter "contribution margin per hectare".
5. Immaterial determining factors (such as quality features) will be monetized and included in the contribution margin.

3.2. Preparation and realization of the economic study

Due to the topic's complexity and the lack of quantitative surveys, this study took an expert-based approach. The study was conducted in three stages, the first of which defined basic rules, as well as the scenarios to be examined. The various scenarios were then calculated using the panel surveys carried out by Kleffmann, as well as external data. A comparison of the results then provides a first insight into the economic impact of a ban on glyphosate.

The following external data sources were used:

- EUROSTAT,
- Federal Ministry for Food and Agriculture in Germany (BMELV),
- Agricultural Market Information Company (AMI),
- Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL),
- AGRAVIS Raiffeisen AG,
- Farmer's Weekly (Great Britain).

In the second stage, these results were discussed and analyzed in the context of so-called "in-depth interviews" (IDI) with independent experts active in the crop protection sector.

Together with the initially calculated results, the expert interviews form the basis upon which final conclusions are drawn in the third and last stage.

Table 8: Realization of the study

Stage	Activity
Stage 1	1. Definition of the basic rules and scenarios that should be investigated 2. Evaluation of the different scenarios 3. Discussion of the first results 4. Preparation of the in-depth interviews (IDI)
Stage 2	5. Implementation of the IDI with plant protection experts in the relevant crops 6. Expert interview summaries
Stage 3	7. Final conclusions and final report

4. Chapter 4 – Economic Impact – Quantitative Results

4.1. Introduction

This chapter describes the economic and environmental impact that a glyphosate ban would have on the production of various crops in Germany. The first section explains the methodological approach and scenarios that will be analyzed. The economic impact on individual cultures and each scenario are presented subsequently in the second section. The last section deals with the environmental impact of a glyphosate ban.

4.2. Methods and scenarios

The economic impact of a glyphosate ban is analyzed using the farms' contribution margin. Scientific studies show that additional soil processing and the use of selective herbicides are necessary to combat emergent weeds in the event of a glyphosate ban (see studies by the University of Giessen, Institute for Agribusiness and Farmers Weekly from the UK). However, this leads to higher direct costs on the part of the farms, since selective herbicides are usually more expensive than non-selective ones (see Kleffmann Panel Study 2016) and additional soil treatment leads to higher diesel consumption. The first scenario examines this problem.

Glyphosate is a versatile active ingredient that can be applied at any time. It can be used very early on weeds, even if they are still in the germination stage. The weeds compete with the crops for sunlight, nutrients and water, which can be particularly scarce at the time of germination (Farmer Weekly, UK in 2017). Many selective herbicides can only be applied after this phase when the weeds are already larger and compete with crops for nutrients. The weeds often deprive crops of important resources by then, which inhibits a healthy development of the crops and ultimately leads to yield losses. In addition, there are some weeds that have developed a resistance to certain herbicides and can only be effectively combated using glyphosate (Weed Science Society of America, HRAC 2016). For example, queensgrass (Elymus repens) is a weed that can result in a 5% drop in yields alone if it is not properly combated. The second scenario also takes account the possible losses in yield that can occur if glyphosate is dispensed with.

In both scenarios, additional soil processing measures are necessary to combat germinating weeds without the aid of glyphosate. The amount of diesel needed for soil cultivation using machines essentially depends on whether a flat-bed/chisel plow or a regular plow is used. The amount of diesel consumed is 7 and 23 liters per hectare, respectively. Time expenditure also fluctuates between 1 and 2 hours per hectare (see KTBL Farm Planning). The calculations are based on the assumption that 8 to 10 liters of diesel per hectare are required for additional soil treatment (for the purpose of pure weed control) and the time required for this is 1.5 hours per hectare. This assumes that herbicide application lasts 0.5 hours per hectare, consuming 1 to 1.5 liters of the respective active substance. We use a diesel price of 1 euro per liter (excluding VAT) since the calculations are carried out VAT-free. The projected producer prices and yields of the respective crops correspond to the average values from 2016.

The environmental impact is based on additional diesel consumption per hectare, which is required for the alternative weed control methods. The EIA (US Energy Information Administration, USA) estimates that with each liter of diesel consumed, 2.68 kg of CO_2 is released. Based on this assumption, we calculate the additional CO_2 emissions per hectare that would be expected with a glyphosate ban.

The above assumptions and scenarios were discussed with experts; these expert opinions were included in the conclusions. To demonstrate the influence of a glyphosate ban on coverage contributions, the following two scenarios were considered:

Scenario 1: Increasing costs through additional tillages and through the use of selective herbicides (no loss of yield)

Scenario 2: Cost increases and yield losses (due to delayed or non-efficient weed control in the case of a glyphosate ban)

In the case of a glyphosate ban, experts recommend the use of other herbicides, as well as mechanical methods for weed control. Table 9 provides an overview of alternative methods proposed by experts for German agriculture.

Table 9: Alternative methods of plant protection in case of a glyphosate ban (the effects of the methods are determined based on the contribution margin per hectare):

Crop	Methods	Expert recommendation	Yield loss
Wheat	Two selective herbicides applications + one tillage	Two selective herbicides applications + one tillage	10%
Barley	Two selective herbicides applications + one tillage	Two selective herbicides applications + one tillage	10%
Silage maize	Two selective herbicides applications + one tillage	Two selective herbicides applications + one tillage	10%
Oilseed rape	One selective/non-seletive herbicide. + one tillage	Two selective/non-seletive herbicides + one tillage	10%
Sugar beets	Two selective herbicides applications + one tillage	Two selective herbicides applications + one tillage	5%
Vine	Three selective herbicides applications + two tillages	Two selective herbicides applications + two tillages	5%
Apples	Three selective herbicides applications + two tillages	Two selective herbicides applications + two tillages	0%

Source: Agriglobe and expert discussion, 2017

As mentioned at the outset, the impact of these methods on the contribution margin per hectare is examined. The equations used for calculation are as follows:

Contribution margin (EUR/ha) = total revenue – (direct costs + operating costs)

Total revenue (EUR/ha) = yield (tons/ha) x price (EUR/tons)

Direct costs (EUR/ha) = costs for seeds + fertilizer + plant protection (herbicides, fungicides, insecticides) + other costs (water, crop insurance etc.)

Operating costs (EUR/ha) = costs for diesel + labour + other variable costs (machinery, maintenance, interests etc.)

4.3. Contribution margin analysis

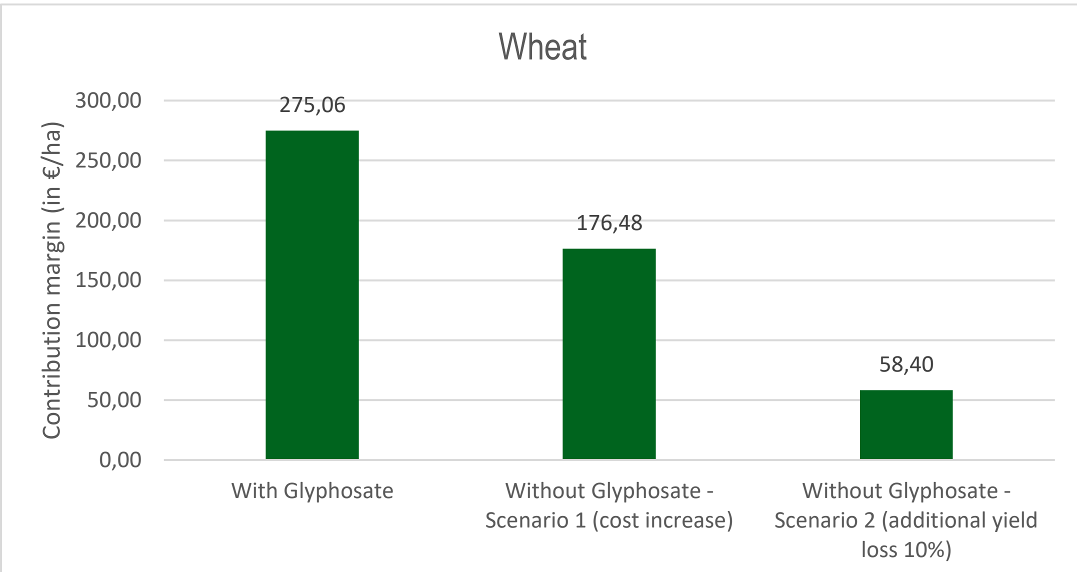
The results of the calculations for each crop of wheat, barley, silage maize, oilseed rape, sugar beets, apples and vine are summarized in the tables below. The contribution margin with glyphosate application was compared with the two scenarios that include a glyphosate ban.

Wheat

Weeds that are more common in wheat and whose control is necessary include silky bent, grass weeds, cleavers, goosefoot, dicotyledons, cornflower, monocotyledons, common poppy, anthemis ssp., and volunteer rape. The "super-developed area" (SDV)[2], treated with herbicides, was 6.8 million hectares in 2016, about twice as large as the entire cultivated wheat area. The SDV treated with glyphosate was 0.48 million hectares, with the active ingredient mainly being used for volunteer rape, dicotyledons, volunteers (cereals), grass weeds, as well as couch grass.

Table 10 shows the contribution margins per hectare for wheat that can be expected in the different scenarios. Due to alternative weed control, the cost of diesel per hectare increases by just under 20% and the cost of herbicides increases by just under 10%. As a result, the contribution margin in scenario 1 will fall by almost 100 euros per hectare, which is almost 36% lower. Assuming a 10% drop in yields, as in scenario 2, the contribution margin per hectare will fall by 78%.

Fig. 8: Contribution margin per hectare wheat



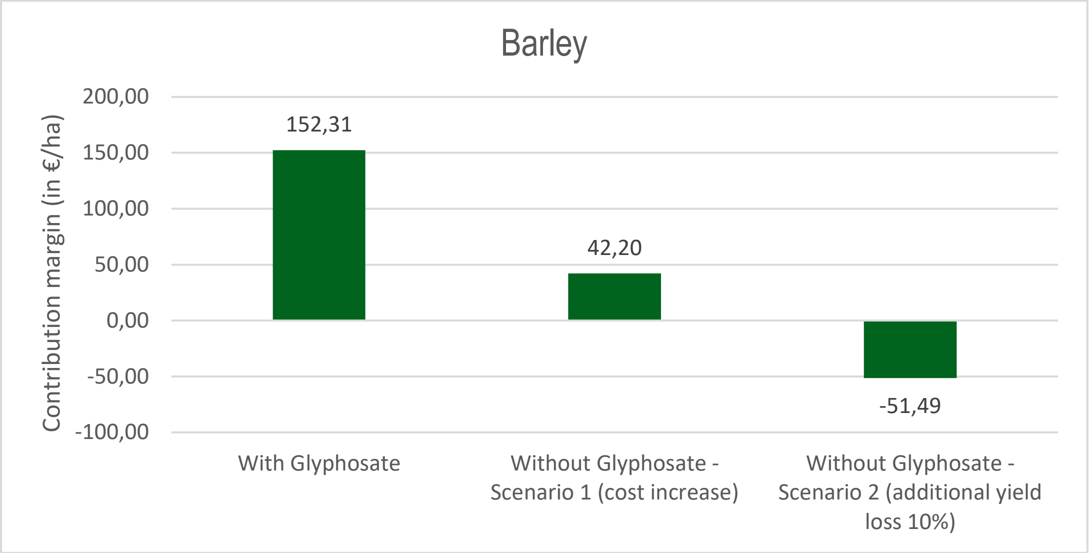
Barley

The weeds increasingly found in barley are: dicotyledons, blackgrass, loose silky-bent, cleavers, mayweed species, volunteer rape, cornflower, monocotyledons, broadleaved weeds and creeping thistle. The herbicide-treated SDV was 2.9 million hectares in 2016, about twice as large as the total cultivated barley area. The SDV treated with glyphosate amounted to 0.1 million hectares, with the active substance mainly being used to combat the emergence of volunteers (cereals), dicotyledons, volunteer rape, grass weeds and couch grass.

Table 11 describes the contribution margin in barley cultivation; the results are quite similar to those for wheat. The contribution margin also decreases during a glyphosate ban due to the increased cost of alternative herbicides and additional soil treatment. In scenario 1, the contribution margin decreases by 72%, while under scenario 2 the margin dips into the negatives. This means that farmers cultivating barley may no longer be profitable if glyphosate is banned.

[2] SDV is defined as the cumulated area that is treated with an active ingredient, i.e. multiple applications are taken into account.

Fig. 9: Contribution margin per hectare barley

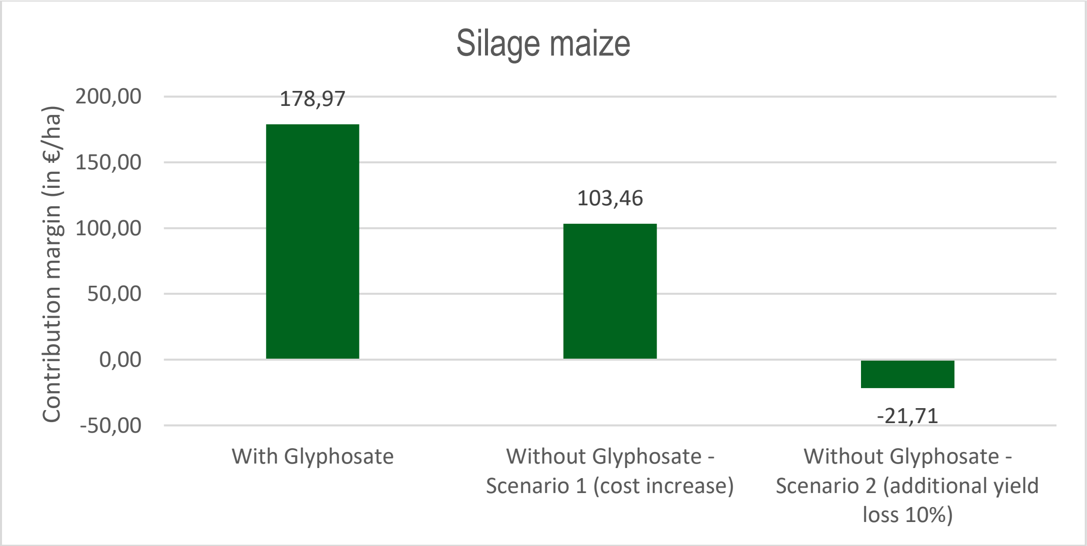


Silage maize

The weeds frequently found in corn are: dicotyledons, digitaria, common orache, monocotyledons, mayweed species, cleavers, couch grass, blackgrass, polygonum ssp., and fat hen. The herbicide-treated SDV was 4.5 million hectares in 2016, about twice as large as the total cultivated area of silage maize. The SDV treated with glyphosate was only 0.04 million hectares, with the active substance mainly being used to combat dicotyledons, volunteers (cereals), weeds and grass weeds, couch grass and monocotyledons.

The quantitative results for silage maize are provided in Table 12. Similarly to barley, the contribution margin can also go into the negatives for silage maize if yield loss occurs as a result of a glyphosate ban. The contribution margin falls by almost half even without including yield losses. It should be noted, however, that the price of silage maize can vary considerably within Germany. The reason for this is that there is no single market for silage maize; the price is often negotiated directly between farmers.

Fig. 10: Contribution margin per hectare silage maize

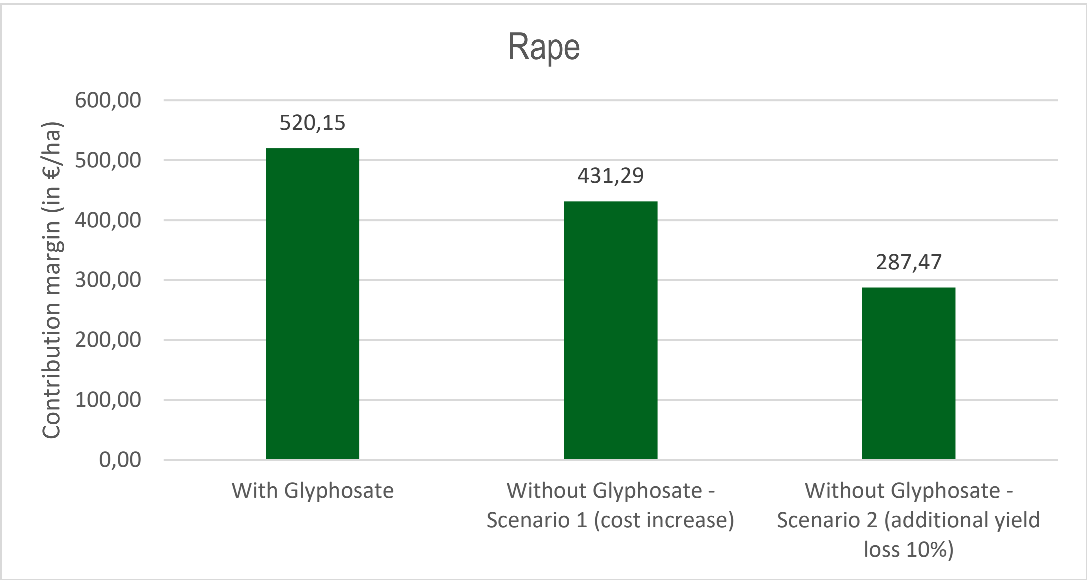


Oilseed rape

The weeds that occur in oilseed rape are: volunteers (cereals), dicotyledons, cleavers, mayweed species, blackgrass, monocotyledons, mustard, cornflower, loose silky-bent, and broadleaved weeds. The herbicide-treated SDV was nearly 2.5 times as large as the total cultivation area of oilseed rape with 3.45 million hectares in 2016. The SDV treated with glyphosate was only 0.13 million hectares, with the active substance mainly being used to combat volunteers (cereals), dicotyledons, monocotyledons, blackgrass and couch grass.

Table 13 contains the contribution margin for oilseed rape. The cost for alternative herbicides does not rise as sharply as for previous cultures. The contribution margin as a result of the glyphosate ban does not decrease to the same extent as with other crops (decrease of 17% in scenario 1). However, assuming a 10% decrease in yields, the contribution margin will also decrease by half for oilseed rape. Despite all this, oilseed rape cultivation remains profitable for farmers in every scenario.

Fig. 11: Contribution margin per hectare oilseed rape

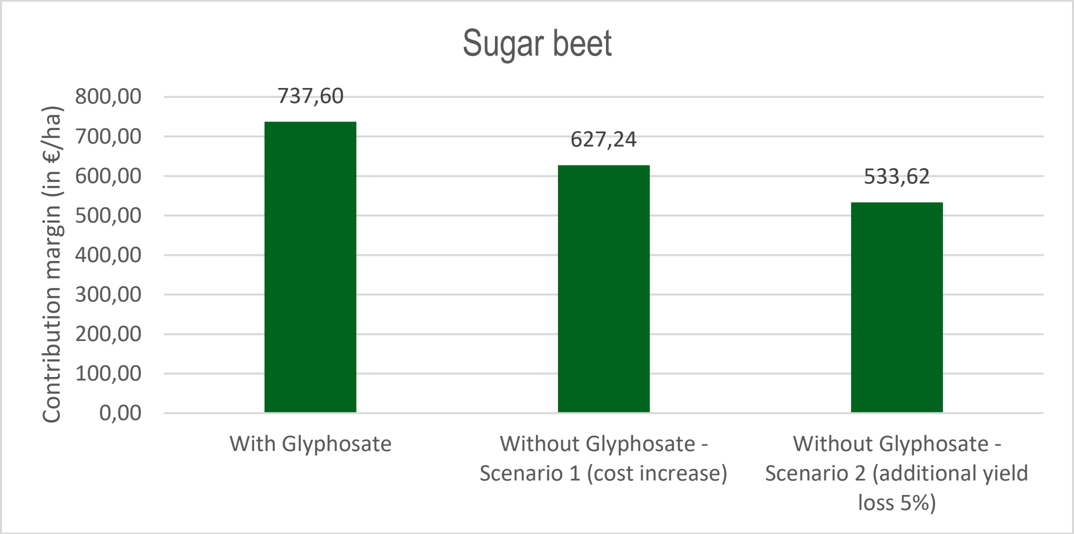


Sugar beets

The weeds that occur most frequently in sugar beets are: dicotyledons, common orache, cleavers, mayweed species, polygonum ssp., volunteer rape, annual mercury, fat hen, digitaria, volunteers (cereals). The herbicide-treated SDV was almost 10 times as large as the entire cultivation area of sugar beets, with 3.21 million hectares in 2016. The SDV treated with glyphosate was approximately 0.1 million hectares, with the active substance mainly being used to combat dicotyledons, volunteers (cereals), weeds and grass weeds, volunteers in gen., as well as monocotyledons.

Table 14 presents the results for sugar beets in Germany. Similar to oilseed rape, the cost of herbicides is only slightly higher for sugar beets, which has to do with the fact that, in this case, many alternative active substances are available. On the other hand, the direct costs are relatively high, mainly due to the additional labor costs. The contribution margin per hectare is thus reduced by 15% in scenario 1 and by almost 28% in scenario 2.

Fig. 12: Contribution margin per hectare sugar beets

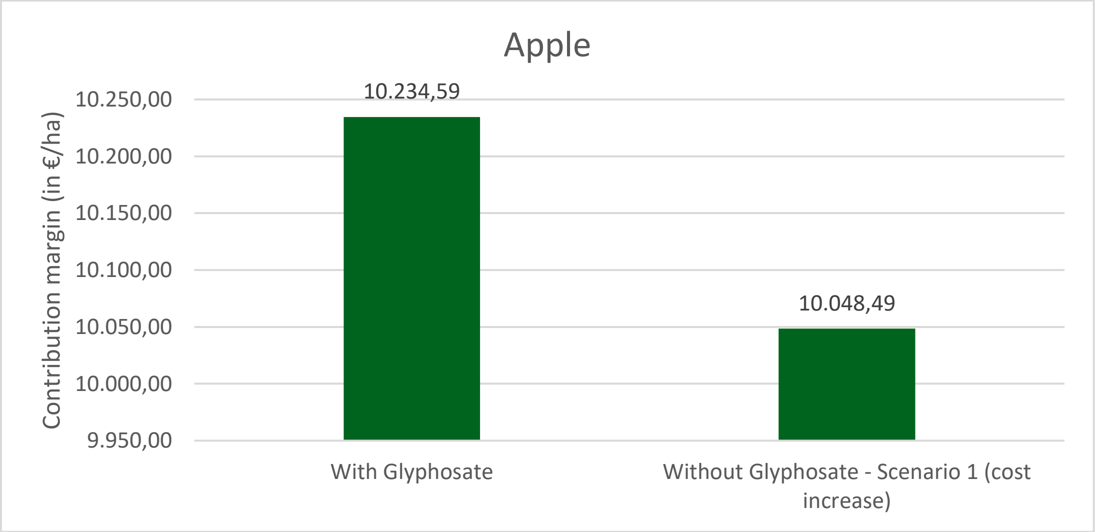


Apples

The weeds increasingly found in apples are: dicotyledons, nettle gen., field horsetail, field bindweed, mayweed species, cleavers, creeping thistle, common orache, digitaria, and couch grass. The SDV treated with herbicides was smaller than the area cultivated with apples, with 0.025 million hectares in 2016. The SDV treated with glyphosate was approximately 0.011 million hectares, with the active substance mainly being used to combat dicotyledons, cleavers, common orache, nettle gen., as well as field horsetail.

Table 15 provides an overview of the impact of a glyphosate ban. It should be noted that additional harvest loss should not be expected with a glyphosate ban; consequently, only scenario 1 will be considered. In contrast to the cultivation of field crops, both revenues and labor costs are very high in apple cultivation. The cost for alternative herbicides and additional tillages is therefore not as important as with other crops. Although the absolute decline in contribution margin (minus 186 euros per hectare) is comparable to that of some field crops, the percentage decline with -2% is very low.

Fig. 13: Contribution margin per hectare apples



Vine

The weeds increasingly found in viticulture are: dicotyledons, field bindweed, amaranth in gener., creeping thistle, common orache, monocotyledons, common chickweed, grass weeds, nettle gen., digitaria. The herbicide-treated SDV was smaller in size than the vine-cultivated area, with 0.085 million hectares in 2016. The SDV treated with glyphosate was approximately 0.06 million hectares, the active substance mainly used to combat dicotyledons, field bindweed, creeping thistle, amaranth in gener., as well as common orache.

The results for vine are provided in Table 16. As in the cultivation of apples, both labor input and revenues are also relatively high. Nevertheless, a glyphosate ban would be more significant than in apple cultivation. In Scenario 1, the contribution margin would decrease by about 20%, while in scenario 2, losses of up to 48% are possible. The absolute decline in the contribution margin is 522.84 euros, the highest value among all crops.

Fig. 14: Contribution margin per hectare vine

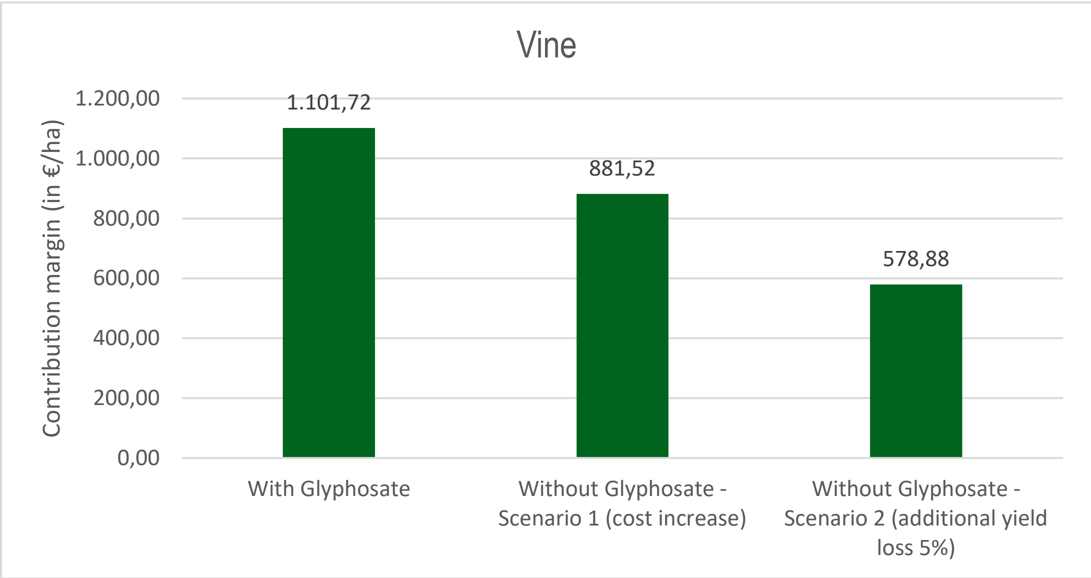


Table 10: Contribution margin for wheat in Germany

Details	Wheat	Without glyphosate	
	With glyphosate	Scenario 1 (cost increase)	Scenario 2 (additional 10 % yield loss)
Price (€/Ton)	167.00	167.00	167.00
Yield (Ton/ha)	8.09	8.09	7.28
A.) Total revenue (€/ha)	1,351.03	1,351.03	1,215.93
Seeds (€/ha)	93.60	93.60	93.60
Fertilizer (€/ha)	327.40	327.40	311.03
Plant protection total (€/ha)	217.08	228.89	228.89
Herbicide (€/ha)	96.76	108.57	108.57
Fungicide (€/ha)	111.61	111.61	111.61
Insecticide (€/ha)	8.71	8.71	8.71
Other direct costs (€/ha)	16.53	16.15	16.15
B.) Direct costs (€/ha)	654.61	666.04	649.67
Costs for work (€/ha)	74.63	103.63	103.63
Costs for diesel (€/ha)	51.99	62.49	62.49
Other costs, i.e. interests etc. (€/ha)	294.74	342.40	341.75
C.) Operating costs (€/ha)	421.36	508.51	507.86
Contribution margin = A– (B + C) (€/ha)	275.06	176.48	58.40
Loss due to glyphosate ban (€/ha)		**-98.59**	**-216.66**

Table 11: Contribution margin for barley in Germany

Details	Barley	Without glyphosate	
	With glyphosate	Scenario 1 (cost increase)	Scenario 2 (additional 10 % yield loss)
Price (€/Ton)	150.00	150.00	150.00
Yield (Ton/ha)	7.17	7.17	6.45
A.) Total revenue (€/ha)	1.075.50	1.075.50	967.95
Seeds (€/ha)	78.40	78.40	78.40
Fertilizer (€/ha)	266.45	266.45	253.12
Plant protection total (€/ha)	155.64	171.01	171.01
Herbicide (€/ha)	53.21	68.57	68.57
Fungicide (€/ha)	72.68	72.68	72.68
Insecticide (€/ha)	29.76	29.76	29.76
Other direct costs (€/ha)	12.94	12.91	12.91
B.) Direct costs (€/ha)	513.43	528.46	515.14
Costs for work (€/ha)	71.20	100.20	100.20
Costs for diesel (€/ha)	48.50	59.00	59.00
Other costs, i.e. interests etc. (€/ha)	290.07	345.64	345.11
C.) Operating costs (€/ha)	409.77	504.84	504.30
Contribution margin = A– (B + C) (€/ha)	152.31	42.20	-51.49
Loss due to glyphosate ban (€/ha)		**-110.11**	**-203.80**

Table 12: Contribution margin for silage maize in Germany

Details	Silage maize	Without glyphosate	
	With glyphosate	Scenario 1 (cost increase)	Scenario 2 (additional 10 % yield loss)
Price (€/Ton)	35.00	35.00	35.00
Yield (Ton/ha)	43.00	43.00	38.70
A.) Total revenue (€/ha)	1,505.00	1,505.00	1,354.50
Seeds (€/ha)	195.80	195.80	195.80
Fertilizer (€/ha)	487.14	487.14	462.78
Plant protection total (€/ha)	101.28	114.75	114.75
Herbicide (€/ha)	101.28	114.75	114.75
Fungicide (€/ha)	0.00	0.00	0.00
Insecticide (€/ha)	0.00	0.00	0.00
Other direct costs (€/ha)	8.42	8.42	8.42
B.) Direct costs (€/ha)	792.64	806.11	781.75
Costs for work (€/ha)	86.71	115.71	115.71
Costs for diesel (€/ha)	66.69	77.19	77.19
Other costs, i.e. interests etc. (€/ha)	379.99	402.53	401.56
C.) Operating costs (€/ha)	533.39	595.43	594.46
Contribution margin = A– (B + C) (€/ha)	178.97	103.46	-21.71
Loss due to glyphosate ban (€/ha)		**-75.51**	**-200.68**

Table 13: Contribution margin for oilseed rape in Germany

Details	Oilseed rape	Without glyphosate	
	With glyphosate	Scenario 1 (cost increase)	Scenario 2 (additional 10 % yield loss)
Price (€/Ton)	410.00	410.00	410.00
Yield (Ton/ha)	3.91	3.91	3.52
A.) Total revenue (€/ha)	1,603.10	1,603.10	1,442.79
Seeds (€/ha)	47.95	47.95	47.95
Fertilizer (€/ha)	317.07	317.07	301.22
Plant protection total (€/ha)	250.54	251.34	251.34
Herbicide (€/ha)	124.46	125.27	125.27
Fungicide (€/ha)	90.84	90.84	90.84
Insecticide (€/ha)	35.24	35.24	35.24
Other direct costs (€/ha)	36.38	35.53	35.53
B.) Direct costs (€/ha)	651.93	651.89	636.04
Costs for work (€/ha)	70.91	99.91	99.91
Costs for diesel (€/ha)	60.55	71.05	71.05
Other costs, i.e. interests etc. (€/ha)	299.56	348.96	348.33
C.) Operating costs (€/ha)	431.02	519.92	519.28
Contribution margin = A– (B + C) (€/ha)	520.15	431.29	287.47
Loss due to glyphosate ban (€/ha)		**-88.86**	**-232.68**

Table 14: Contribution margin for sugar beets in Germany

Details	Sugar beets	Without glyphosate	
	With glyphosate	Scenario 1 (cost increase)	Scenario 2 (additional 5 % yield loss)
Price (€/Ton)	27.40	27.40	27.40
Yield (Ton/ha)	76.20	76.20	72.39
A.) Total revenue (€/ha)	2,087.88	2,087.88	1,983.49
Seeds (€/ha)	173.16	173.16	173.16
Fertilizer (€/ha)	345.28	345.28	334.92
Plant protection total (€/ha)	298.64	307.99	307.99
Herbicide (€/ha)	266.24	275.59	275.59
Fungicide (€/ha)	25.14	25.14	25.14
Insecticide (€/ha)	7.26	7.26	7.26
Other direct costs (€/ha)	32.28	32.28	32.28
B.) Direct costs (€/ha)	849.37	858.71	848.35
Costs for work (€/ha)	63.37	99.62	99.62
Costs for diesel (€/ha)	71.33	81.83	81.83
Other costs, i.e. interests etc. (€/ha)	366.21	420.49	420.07
C.) Operating costs (€/ha)	500.91	601.93	601.52
Contribution margin = A– (B + C) (€/ha)	737.60	627.24	533.62
Loss due to glyphosate ban (€/ha)		**-110.37**	**-203.99**

Table 15: Contribution margin for apples in Germany

Details	Apples	Without glyphosate
	With glyphosate	Scenario 1 (cost increase)
Price (€/Ton)	560.00	560.00
Yield (Ton/ha)	31.00	31.00
A.) Total revenue (€/ha)	17,360.00	17,360.00
Seeds (€/ha)	--	--
Fertilizer (€/ha)	266.53	266.53
Plant protection total (€/ha)	498.69	519.51
Herbicide (€/ha)	42.24	63.06
Fungicide (€/ha)	313.25	313.25
Insecticide (€/ha)	143.20	143.20
Other direct costs (€/ha)	6.38	6.80
B.) Direct costs (€/ha)	771.60	792.84
Costs for work (€/ha)	5,800.00	5,887.00
Costs for diesel (€/ha)	200.00	222.00
Other costs, i.e. interests etc. (€/ha)	353.81	409.66
C.) Operating costs (€/ha)	6,353.81	6,518.66
Contribution margin = A– (B + C) (€/ha)	10,234.59	10,048.49
Loss due to glyphosate ban (€/ha)		**-186.10**

Table 16: Contribution margin for vine in Germany

Details	Vine	Without glyphosate	
	With glyphosate	Scenario 1 (cost increase)	Scenario 2 (additional 5 % yield loss)
Price (€/Ton)	501.50	501.50	501.50
Yield (Ton/ha)	12.22	12.22	11.61
A.) Total revenue (€/ha)	6,127.31	6,127.31	5,820.95
Seeds (€/ha)	--	--	--
Fertilizer (€/ha)	178.98	178.98	175.40
Plant protection total (€/ha)	247.81	262.96	262.96
Herbicide (€/ha)	82.01	97.15	97.15
Fungicide (€/ha)	104.05	104.05	104.05
Insecticide (€/ha)	61.75	61.75	61.75
Other direct costs (€/ha)	6.38	6.80	6.80
B.) Direct costs (€/ha)	433.16	448.74	445.16
Costs for work (€/ha)	3,552.50	3,668.50	3,668.50
Costs for diesel (€/ha)	122.00	145.00	145.00
Other costs, i.e. interests etc. (€/ha)	917.93	983.55	983.41
C.) Operating costs (€/ha)	4,592.43	4,797.05	4,796.91
Contribution margin = A– (B + C) (€/ha)	1,101.72	881.52	578.88
Loss due to glyphosate ban (€/ha)		**-220.20**	**-522.84**

Figures 15 and 16 provide an overview of the effect that a glyphosate ban would have on farms' contribution margins. The largest absolute decline in contribution margins in scenario 1 is expected in viticulture, followed by apple cultivation and sugar beets. However, the picture changes if one looks at relative decline. In this case, the decline in barley is highest at over 70%, followed by silage maize (42% decline) and wheat cultivation (36% decline).

In scenario 2, the absolute decline in the contribution margin is also highest in viticulture, which was more than twice as high as oilseed rape and wheat at 523 euros per hectare. Viewed relatively, the order also changes here, since the absolute contribution margin in viticulture is very high. Barley and silage maize have the largest percentage decline in contribution margin with 133% and 112%, respectively. The expected decline for both crops is so staggering that the contribution margin falls into the negatives and cultivation becomes unprofitable. The lowest relative decline is observed in apple cultivation due to the difference in cost structure.

Fig. 15: Absolute decline in contribution margins (in €/ha)

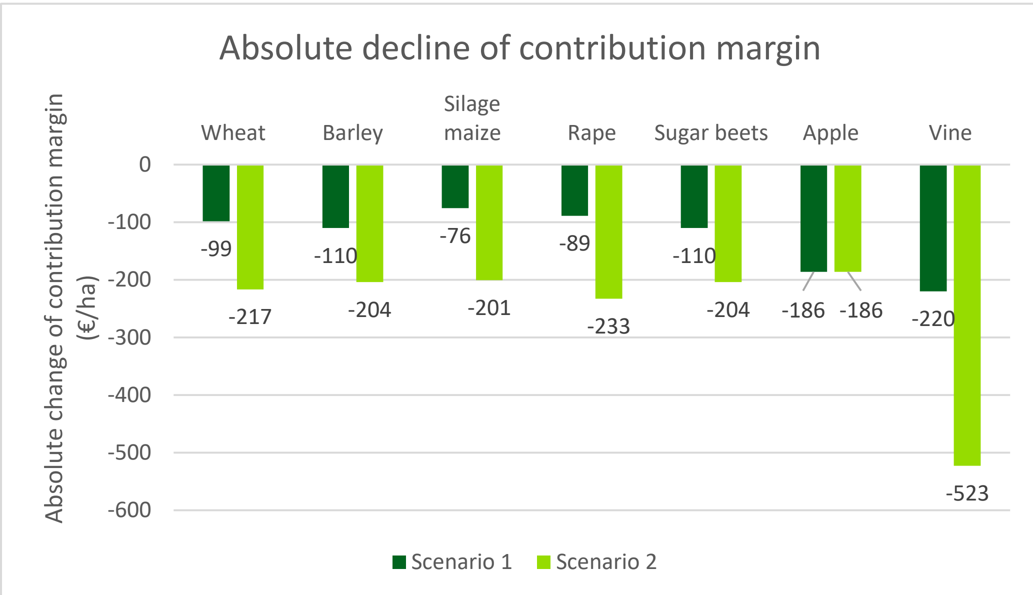
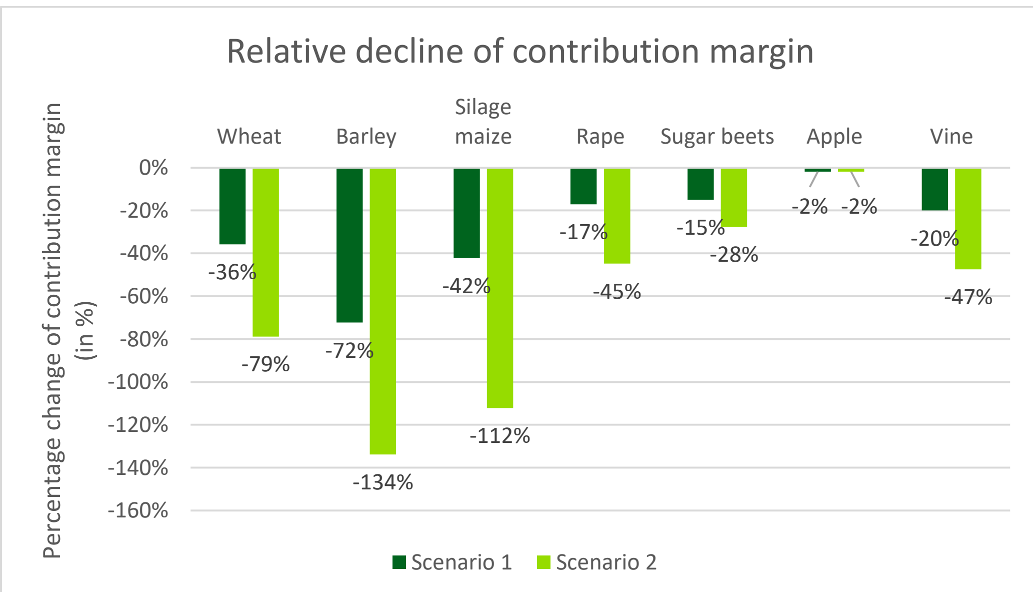


Fig. 16: Relative decline in contribution margins

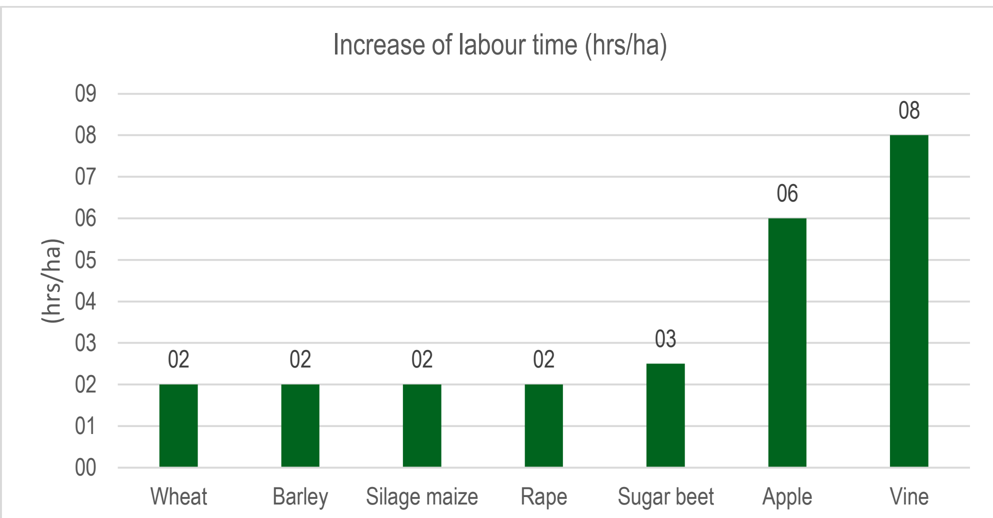


Since a ban on glyphosate is associated with additional soil treatment, not only does the required quantity of diesel fuel increase, but the amount of work required also increases. The following table shows how much additional work is required for each crop. An additional workload of 2 hours per hectare is to be expected for field crops. As is to be expected, the workload is particularly high in the case of permanent cultivation for vine and apples. This is because viticulture is often found on very steep slopes and harvesting is very time-intensive.

Table 17: Impact of a glyphosate ban on workload

Crops	Workload with glyphosate (in hrs/ha)	Workload with glyphosate (in hrs/ha)	Additional workload (in hrs/ha)
Wheat	5.15	7.15	2.00
Barley	4.91	6.91	2.00
Silage maize	5.98	7.98	2.00
Rape	4.89	6.89	2.00
Sugar beets	4.37	6.87	2.50
Apples	400.00	406.00	6.00
Vine	245.00	253.00	8.00

Fig. 17: Increase in the workload in the case of a glyphosate ban



4.4. Environmental impact

A possible ban on glyphosate would not only have an economic, but also an environmental impact. Due to increased number of tillages and herbicide use, which are necessary for effective control of the weeds in the case of a glyphosate ban, more diesel is consumed, which drives CO_2 emissions upwards (see Table 18 and Fig.18). Diesel consumption is thus increased by 10.4 liters per hectare for field crops. Because about 2.86 kilogram of CO_2 emissions are released per liter of diesel CO_2 emissions increase by 28.14 kilograms per hectare in the case of a glyphosate ban. The CO_2 emissions of apple and vine cultivation also increase since soil cultivation is considerably more complex and more than 20 liters of diesel are required per hectare in addition. The increase in CO_2 emissions is also more than twice as high as in field crops with 58.96 kilograms per hectare for apple cultivation and 61.64 kilograms per hectare for vine cultivation. Assuming that about 3.6 million hectare (corresponds to roughly 30% of arable land)[3] are being treated with glyphosate in Germany, there are additional CO_2 emissions of 100.800 tons, which would occur solely due to arable farming.

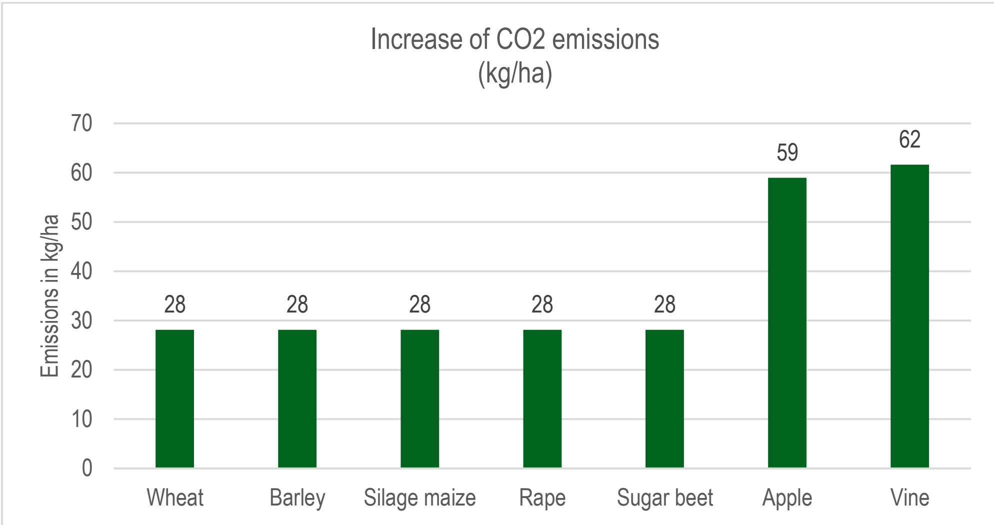
Putting this in relation to CO_2 emitted when driving, this would mean that the additional CO_2 emissions amount to 0.118 kilograms per kilometer. For reference, the increase in CO_2 emissions per hectare in case of a glyphosate ban can be compared to a drive of 233 to 522 kilometres (depending on the cultivated crop). Projecting this number to the total cultivated area in Germany, this would account for 838.800 additional kilometers, which is tantamount to circling the globe 21,000 times and corresponds to the sixfold distance between earth and sun.

Table 18: Increase in CO_2 emissions during a glyphosate ban in Germany (in kg/ha)

Culture	Increase in diesel consumption (in liter/ha)	CO_2 emission per liter of diesel (in kg)	Total increase in CO_2 emissions (in kg/ha)
Wheat	10.50	2.68	28.14
Barley	10.50	2.68	28.14
Silage maize	10.50	2.68	28.14
Rape	10.50	2.68	28.14
Sugar beets	10.50	2.68	28.14
Apples	22.00	2.68	58.96
Vine	23.00	2.68	61.64

[3] The assumption that 30% of farmland are being treated with glyphosate in Germany is based on the studies:
- P. Michael Schmitz, Hendrik Garvert: *Die ökonomische Bedeutung des Wirkstoffes Glyphosat für den Ackerbau in Deutschland*. In: *Journal für Kulturpflanzen*. Band 64, No. 5, 2012, pp. 150-162.
- Horst Henning Steinmann, Michael Dickeduisberg, Ludwig Theuvsen: *Uses and benefits of glyphosate in German arable farming*. In: *Crop Protection*. Band 42, 2012, pp. 164-169.

Fig. 18: Increase in CO_2 emissions through alternative methods for weed control



A further environmental effect can be observed in the increasing danger of soil erosion, which is to be expected as a result of increased soil tillage by ploughing. According to the European Environment Agency, almost 130 million hectares of land in the EU are affected by rainfall and flooding as a result of soil erosion and 42 million hectares are threatened by wind erosion. Soil erosion exceeds 10 tons per year and per hectare at about 20% of the area. These figures would increase further in the case of a glyphosate ban because the soil is increasingly exposed to the elements during conventional tillage (in particular by ploughing) than in the case of conservation tillage. However, the latter is hardly practical if glyphosate is no longer available for farmers.

5. Chapter 5 – Economic Impact – Expert Opinions

5.1. Introduction

This chapter provides a summary of the expert interviews carried out within the framework of this study. The experts, which include academic experts and specialists for plant protection, were asked to assess their consequences for a ban on glyphosate in German farmland. Their opinions on the various points are summarized in the following sections.

5.2. Economic and environmental Impacts

All experts agree that a ban on glyphosate leads to an increase in operating costs and labor on part of the farms. The main reason for this is the increasing share of mechanical soil cultivation, as well as the greater working depth in the soil (for example, by means of chisel ploughs), which ultimately leads to increased production costs. The share of the mulch sow would decline significantly without the availability of glyphosate.

"If [glyphosate] is no longer available, then more ground work will be done, this could mean ploughing, but in any case, there will definitely be more machine usage, which means more diesel, but also deeper intervention in the soil"

The lack of flexibility, which is offered by glyphosate in production could also increase production costs, according to experts.

"It would certainly lead to difficulties in production because I am now much more flexible with glyphosate."

The increasing mechanical soil cultivation also leads to more soil erosion and decreasing soil fertility. There is a considerable danger of erosion for row crops, such as sugar beets, corn or potatoes, due to the increase in heavy rainfall and the lack of soil cover in the spring. A topography with already low slopes leads to considerable soil loss of up to 50 tons per hectare per year. Soil erosion of up to 10 tons per hectare per year could also occur in crop cultivation, which can only be effectively avoided by means of a total herbicide, such as glyphosate.

"Ploughless soil treatment provides good protection against erosion. [...] The availability of glyphosate is an essential component of ploughless agriculture."

5.3. Impact on food production and the import/export of food in Germany

Many experts believe that a glyphosate ban would also have an impact on food production and the import/export of food in Germany. Due to increasing plant-building problems (resistance, late sowing, increased summering, expansion of fruit sequence), a loss of 5 to 10% should be expected in the medium term as a result of a glyphosate ban in Germany. These changes (ceteris paribus) are expected to lead to a decline in cereal (7%) and rapeseed (10%) production in the EU, with significant implications for trade equilibrium. The net export of wheat would probably tend towards zero, and in the case of oilseed rape and coarse grain (feed), the EU could become a net importer. The latter could lead, among others, to a rise in the price of certain products.

5.4. Impact on weed resistance

Increased weed resistance is a problem identified by all experts equally in the case of a glyphosate ban. This has, for example, been the case for black grass, which is a major problem especially in Northern Germany and has already developed a resistance to other herbicides.

"Black grass is such an issue because we absolutely need glyphosate as a remedy against black grass on the stubble"

According to an expert, glyphosate use is imperative to maintain the yield level. Otherwise, additional quantities of alternative herbicides would have to be used, but their limited spectrum of effects would lead to further resistance in the medium term.

"If other herbicides are used even more frequently in order to combat weed, resistance problems that are already present in the sulfonylureas, [...] it will not simplify the problem."

In addition, sowing winter cereals would have to be postponed further in autumn in order to combat, in particular, tufted tans by using additional plant-building measures. The risk of worsening seed conditions would increase and lead to lower yields. Therefore, summer crops would increase and lead to significantly lower yields per hectare.

5.5. General evaluation of glyphosate from personal experience

Almost all experts conclude that glyphosate is an essential building block for weed control in agriculture. Concerning flexibility in application and the spectrum of activity, experts agree that there is no adequate substitute to glyphosate. Alternative herbicides are not equally effective in combating weeds and carry further risks. In order to ensure the safe handling of glyphosate, Germany takes a pioneering role with regards to the requirements for glyphosate use.

One expert emphasizes that the active substance glyphosate is ideal, from a commercial and plant-oriented point of view, to enable competitive and erosion-reducing crop operations. Increased intervention in soil, as well as a further increase in herbicide expenditure, leads to additional costs. However, it should also be noted that a loosening of the crop rotation with increased intercropping before summering offers the possibility of improved weed control and can increase biodiversity. These arable measures can be considered desirable in combination with reduced glyphosate use within the crop rotation. The maintenance of the availability of the active substance glyphosate is strongly recommended in order to maintain competitiveness and entrepreneurial diversity in plant-based decisions, as well as to combat resistance in weeds.

6. Conclusions

Glyphosate has already been developed and marketed over 40 years ago, and it is still regarded as one of the most modern and important chemical substances in agriculture today. Ever since, scientific risk assessment of glyphosate have been conducted on a regular basis, not only within Germany, and the EU but throughout the world. The EU has currently not yet decided upon the renewal of the authorization with the Union. Against the backdrop of a potential glyphosate ban in the EU, this study examined the economic impact for individual farms in Germany. Both the calculated contribution margins, as well as the expert interviews show a unambigous picture: A glyphosate ban would deprive farms of one of their most important and simplest tools for combating weeds and would have an enormous economic impact depending on crop cultivation. Alternative methods of weed control are primarily additional soil treatment and the use of alternative herbicides, which are not always available and are less effective. Both of these methods are associated with rising costs for farms, especially as additional use of machinery will lead to increased use of diesel and labor costs. However, the additional costs can vary greatly among crops. Even if the absolute cost reduction in the case of permanent crops, such as apple and vine, is highest because of complex cultivation, field crops, such as barley and silage maize, would be particularly affected by a glyphosate ban. The contribution margin from farms cultivating these crops would fall by 40% to 70% per hectare due to the increased costs. The loss is even more pronounced if we take into account the yield loss of 5% to 10% that can result from resistant weeds or delayed sowing. In this case, the contribution margin for barley or silage maize can even go into negative digits, which would have a significant impact on the entire agrilcultural structure in Germany. Farms that are no longer profitable could be forced to stop their production or to grow other, less promising crops. The latter can, however, be difficult due to crop rotation. An additional social component is the growing workload, which not only reduces the cost of production, but also extends farmers' working hours.

Finally, a glyphosate ban would also have not only economic consequences, but an environmental impact as well. Additional use of machines is always associated with increased diesel consumption, which in turn means increased CO_2 emissions. The calculations show that the additional output per hectare runcounter to measures implemented in order to decrease greenhouse gas emissions. A further environmental consequence is the increased risk of soil erosion. The increased use of machinery leads to soil compaction, which in turn leads to more soil erosion and lower soil quality and would affect soil biodiversity. This could lead to further loss in yields for farmers in the long term. Expert indicated without any exception that increased weed resistance towards other herbicides would be a crucial issue. Plant protection products containing glyphosate are valued as an important instrument in compating resistent weeds, such as amaranth. If the active substance was no longer available, this would have significant negative impacts on arable production.

Considering the economic analysis as well as the expert opinions, it can therefore be concluded that agriculture industry, which does in fact take into account the three pillars of sustainability, is hardly realistic without the use of glyphosate.