Industrieverband
Agrar

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Social benefits of plant protection in Germany

Preface

Some issues in the public debate are rather driven by emotions than by facts. No doubt, the use of plant protection products is one of them.

If we want to enter a discussion based on facts we need verifiable data. While experts and practitioners believe they know the benefit of modern plant protection, no one has ever made the effort to calculate it by Euro and Cent.

In 2011, this was the starting point for a long-term cooperation (of IVA) with the authors of this study, Prof. Dr. Dr. h.c. Harald von Witzke (Humboldt University of Berlin) and Dr. Steffen Noleppa (agripol).

Four research reports have been published since, demonstrating that modern plant protection delivers a considerable contribution to all aspects of sustainability – economic, social and ecological.

This publication sums up the reports' most interesting findings.

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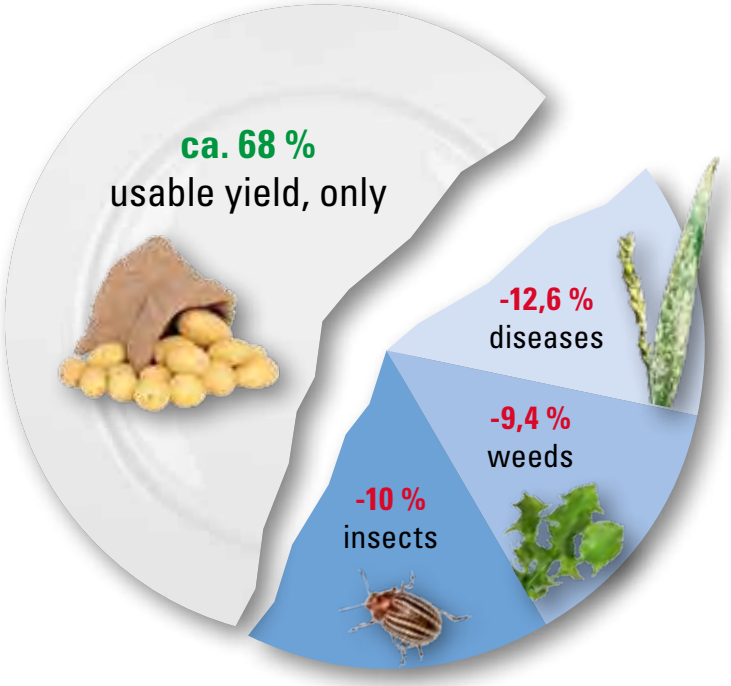
Scope and objective of the study

The public debate on pros and cons of chemical-synthetic plant protection (in the following: plant protection) mainly focuses on risks regardless if they are real or merely perceived, but tends to overlook opportunities and chances of this technology. Thus, it is not surprising that for 40 media reports on plant protection with a negative spin, there is just one pointing out its positive effects. The benefits of plant protection are, if at all, taken for granted but not credited as a technological advancement.

This is an improper approach as plant protection fundamentally contributes to numerous social benefits. First of all: It protects and increases our yields! Modern plant protection management prevents huge crop losses on a global scale. Conservative estimates assume that yields would decrease by one third without meaningful plant protection. Losses resulting from a lack of plant protection are on the one hand nearly equally attributed to the three big 'enemies' of agricultural crops – weeds, insects and diseases – which, on the other hand can be effectively controlled and combated through the use of herbicides, insecticides and fungicides.

As evident as this benefit may be, agro-economic research has so far fallen short of *measuring* the economic value of plant protection for farmers, processing, marketing as well as consumers and, altogether, the social value of plant protection.



Losses of up to 32 per cent without comprehensive plant protection

Source: Oerke, 2004

This was the starting point of the research project 'Social Benefits of Plant Protection in Germany' that has been initiated by Industrieverband Agrar e.V. (IVA) and implemented by agricultural economists of Humboldt University Berlin in cooperation with agripol – network for policy advice GbR. Four research reports have been published in the last months. This report summarizes the results, intelligible also for readers outside the scientific community. Links to the four individual research reports are to be found at the end of this summary.

The above-mentioned project is meant to substantially contribute to a discussion of the social benefits of plant protection – based on reproducible findings and scientific facts. In particular, the results are to provide important information that can facilitate an objective public debate on the benefits and costs of plant protection and to point out the importance of plant protection for specific societal goals. The working hypothesis pursued in this project and its four sub-studies is that macroeconomic development and social welfare, mitigation of climate change and increasing food security, protection of natural resources and environmental protection will be no trade-offs but offers synergies if plant protection is done targeted and if plant protective agents are properly applied on-farm.

Against this background, firstly essential data and methods providing the base of the various necessary analyses are to be outlined in short. Thereafter, market effects resulting from applied plant protection in Germany are identified. These are mainly market quantity and price effects, but also social welfare impacts which can be considered as a contribution of plant protection to the gross domestic product. From these general economic effects at market level income effects at farm level, i.e. in agricultural holdings, result. These will be described later and discussed for typical farms in Germany.

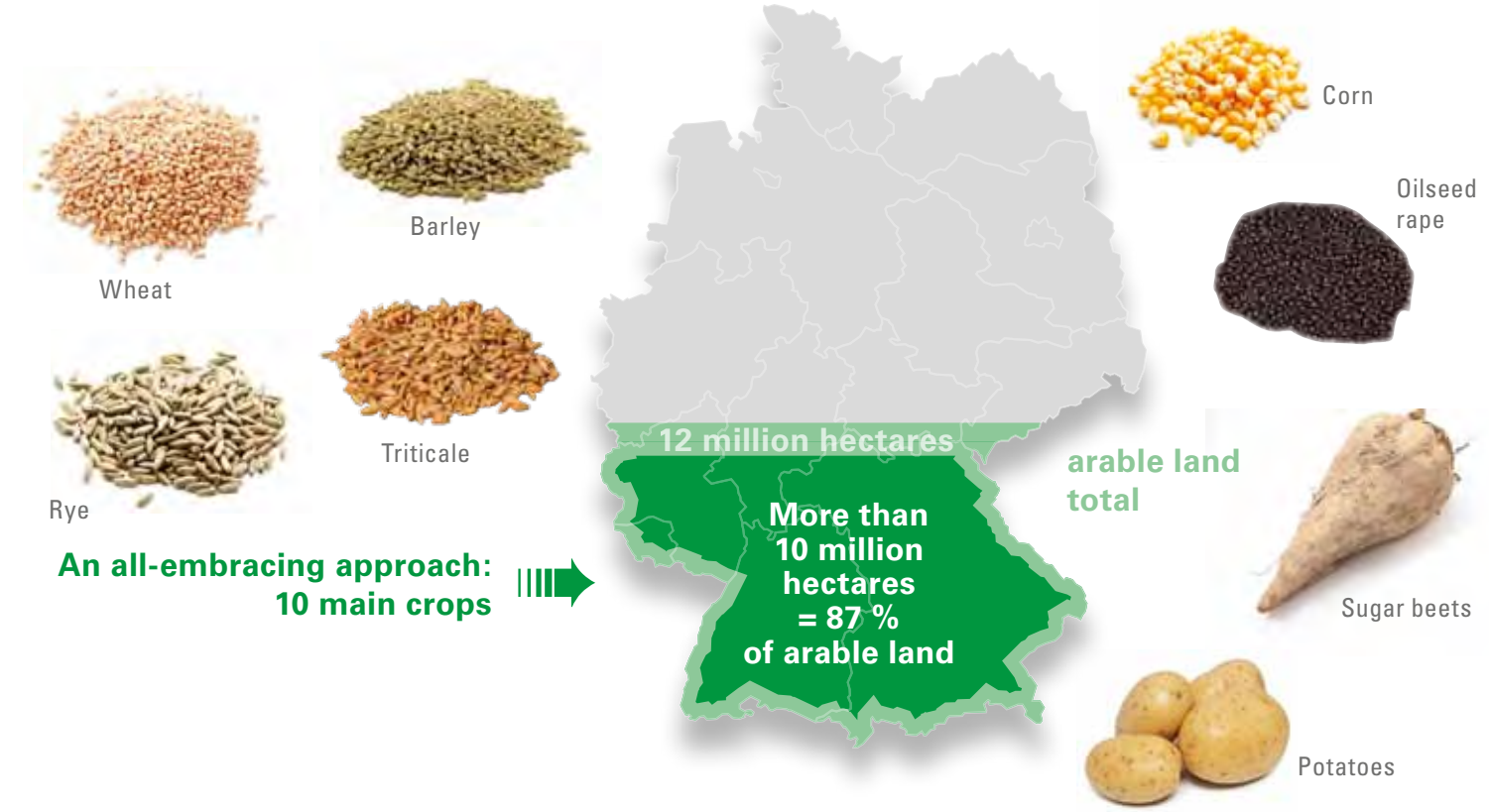
However, plant protection in Germany does not only have an economic impact, but also substantial environmental effects that are not evident at first glance. Thus, it is possible to describe climate effects, based on the assumption that plant protection saves limited natural resources, particularly land through higher yields. Moreover, it can be shown that as a consequence, carbon still sequestered in natural habitats would not be released. Finally, it can be referred to some energy effects, as plant protection on the one hand does require energy, but on the other hand supports the utilization of solar energy. All these effects can be balanced.

Objective data and reliable scientific methods

Two scenarios have been defined to analyze the described effects. Their assessment is to facilitate a closer look at the benefits of modern plant protection in Germany.

- The first scenario 'crop production with vs. without fungicides' shows the specific importance of plant protection using the example of fungi controlling agents. It analyses how crop production in Germany would change if no fungicides are applied while all other inputs remain unchanged.
- The second scenario 'conventional vs. ecological farming' illustrates the effects of diverging plant protection management strategies (chemical-synthetic vs. ecological plant protection) in the context of the two different farming systems. It analyses both, a complete and a partial (20 %) conversion from conventional to ecological farming.

The study claims comprehensiveness as all main crops in Germany will be included in the analyses. In particular, it has been possible to describe the effects of plant protection for all major cereals, including corn, as well as for oilseed rape, sugar beets and potatoes by generating suitable scientifically verified and publicly available data. This means, the following analysis comprises more than ten million hectares, i.e. approximately 87 % of the arable land in Germany.



For the scenario 'crop production with vs. without fungicides', more than 13,000 experimental series on seed-variety trials for the above-mentioned major arable crops at different sites all over Germany were evaluated. Over 250 publications of regional offices and of the publicly funded Chambers of Agriculture, which are in charge of such seed-variety trials, were reviewed. To our knowledge, such a comprehensive analysis of impartial data describing the effects of plants protection has never been done in Germany before.

The scenario 'conventional vs. ecological farming' uses official statistics of the German federal government. In particular, data of the farm accountancy data network ('Testbetriebsnetz') were used. These are annually updated information on the situation of agriculture, i.e. data – internationally standardized and regulated by law – gathered from real farms. Within the official statistics of the farm accountancy data network, conventional and ecological farms have consistently been compared in the past years. By eliminating data deviations from different land quality and/or farm sizes, only 'similar' farms were compared and used for the own analysis.

Using these data, yield differences – both for 'crop production with vs. without fungicides' and 'conventional vs. ecological farming' – were derived and are described in the following chapter of this report. However, before the analysis itself, the identified yield differences, although considered reliable, were stress-tested. Aligning the calculated differences with the results of other scientific publications revealed that the yield differences determined for Germany are rather conservative and by no means over-assess reality.

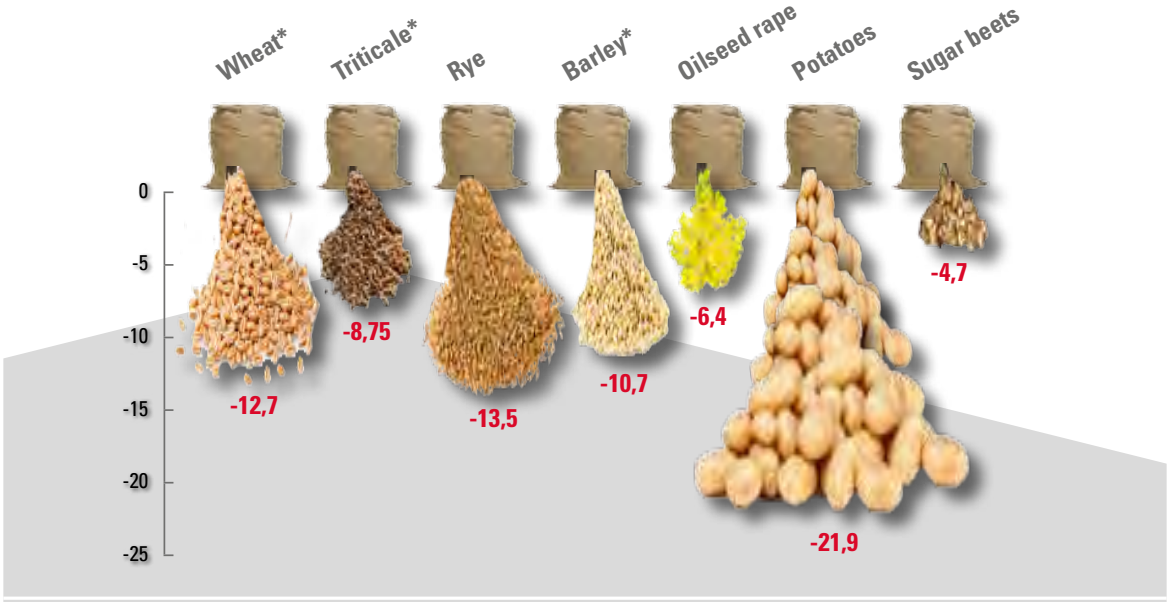
The analysis of the four above-mentioned effects – market and income as well as climate and energy effects – resulting from yield differences, exclusively uses standard methods in the particular academic area. All essential analytical techniques have been issued peer reviewed publications in the past years or have been internationally and widely accepted in agricultural economics and in science for a long time. This applies to deriving market effects using so-called multi-market models in connection with the concept of the 'social welfare theory' and to deriving income effects using calculation approaches such as full cost analysis and 'constructed normal valuing'; and in the same way it applies to assessing climate effects based on the instrument of calculating and analyzing 'indirect land use changes' and to balancing energy effects with energy efficiency analyses. All these approaches are considered academic standards.

Despite a generally satisfying data base and applicable, reliable analytical concepts, a few assumptions had to be made. All the assumptions and the referring definitions are completely and transparently described in the four sub-studies of the project and claim to be formulated conservatively as well, in order not to overestimate potential benefits of plant protection.

Plant protection products improve global food supply and increase economic prosperity

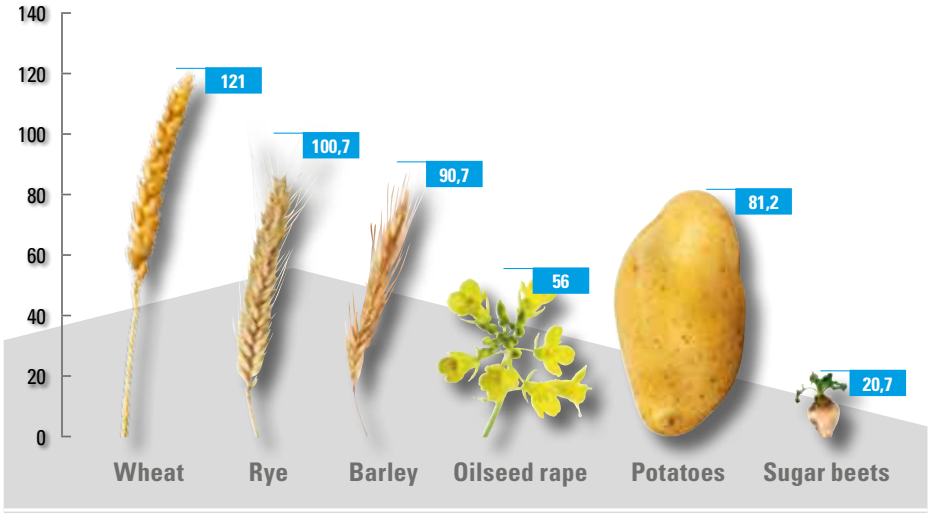
The primary effect of applying plant protection products is the yield effect. Modern agents allow better and more stable yields per hectare. This effect has been described in numerous studies and has been clearly specified for Germany through this project. The calculated yield differences for both scenarios 'crop production with vs. without fungicides' and 'conventional vs. ecological farming' can be described as follows:

- When withdrawing fungicides without alternative from the portfolio of modern plant protection management, considerable yield losses have to be documented for Germany. The decrease in yields on average of all arable crops – weighted with the respective area shares – amounts to approximately 10 %. However, the losses differ substantially between the particular crops: The yield losses attributed to the lack of the respective agents accounts for just below 5 % loss in sugar beets, in wheat for approximately 13 %, and in potatoes for more than 20 %. It has to be noted that these are extremely conservative estimates, since – as stated above – data from official seed-variety trials were used for calculating the yield effects. Standardized seed-variety trials are carried out under nearly ideal management conditions. Consequently, the negative yield effects would be much higher on a 'normal' farm, without fungicides.

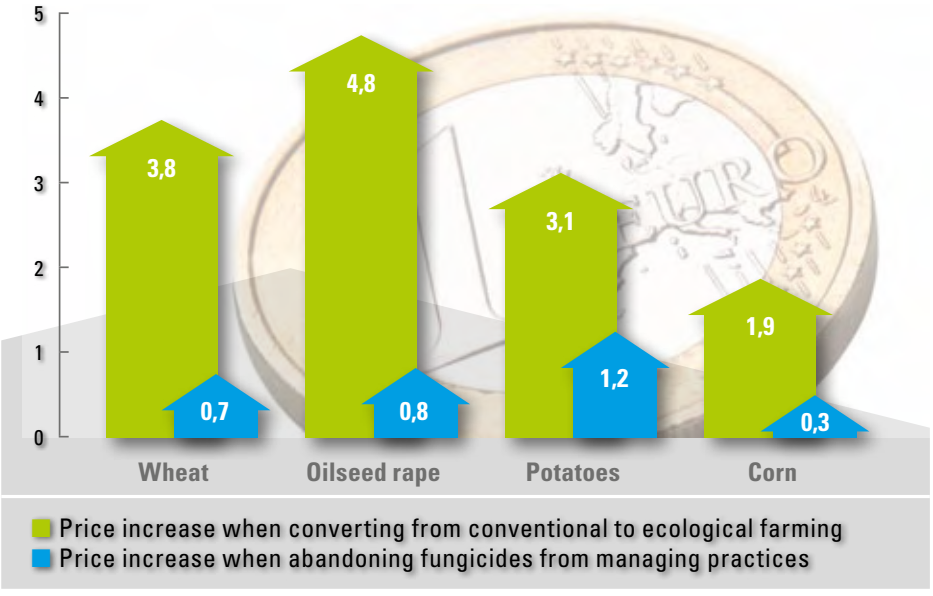


* Consolidated values for winter and summer varieties

- In the scenario 'conventional vs. ecological farming', yield losses are far more substantial. The yields per hectare achieved under conventional farming practices in Germany amount to nearly double the yields in ecological farming on recent years' average. In other words: In Germany ecological farming achieves only 52 % of the yields of conventional farming on average of all arable crops, if comparable farms in terms of location and size are used for analysis. Crop-specific differences become obvious, too: More than double the yield of wheat can be achieved in conventional farming, with respect to oilseed rape the yield amounts to more than 50 % in conventional agriculture, and with regard to sugar beets 'still' 20 % more of what can be harvested in ecological farming as possible in conventionally operated farms.



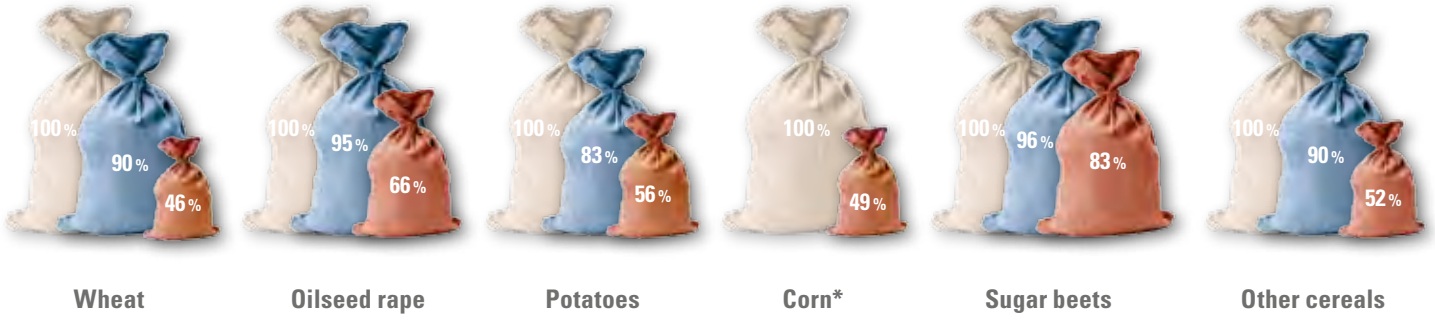
Yield failures in Germany, as small as the country may be on a global scale, would result in noticeable price increases on international agricultural markets. A complete conversion of farming systems in German agriculture from conventional to ecological farming would account for a global agricultural price increase of 5 %. A 20 % conversion of arable land would still cause 1 % higher market prices. This equals the price effect of abandoning the use of fungicides in German agriculture.



However, not only price increases on the world markets would be the consequence of phasing out modern plant protection. The respective changes in plant protection management in Germany would also cause severe losses in quantity attributed to crop failures. The losses in quantity would indeed be extremely high.

Thus, ecological farming in Germany, given a complete conversion of all arable land, would reduce market supply by approximately 12 million tons of wheat, and the abolishing of fungicides in Germany would account, e.g., for a decrease of 2 million tons of potatoes per year.

Huge yield losses when abandoning modern plant protections



* Corn: No fungicide PPPs registered during the analysed time period.

This might not be a threat worth to be mentioned with respect to a prosperous economy as the German one: Missing quantities could easily be acquired on the world market. However, this amount would be missing for food supply on a global scale and especially in poor countries. As simple as it might be: It can be concluded that plant protection secures food, especially in periods of increasing world population. Two examples may illustrate this point:

- With a worldwide average wheat consumption of 66 kg per year and capita, 12 million tons of wheat less in Germany due to a complete conversion to ecological farming, e.g., means undersupply in the commodity basket of 184 million people.
- And with a global potato consumption of 32 kg per year and capita, the amount that is produced less in Germany due to a conversion to ecological farming means an undersupply in the food basket of 155 million people.

In other words: By abolishing modern plant protection in Germany, an annual wheat production for 184 million people will be omitted and an annual potato production for 155 million people.

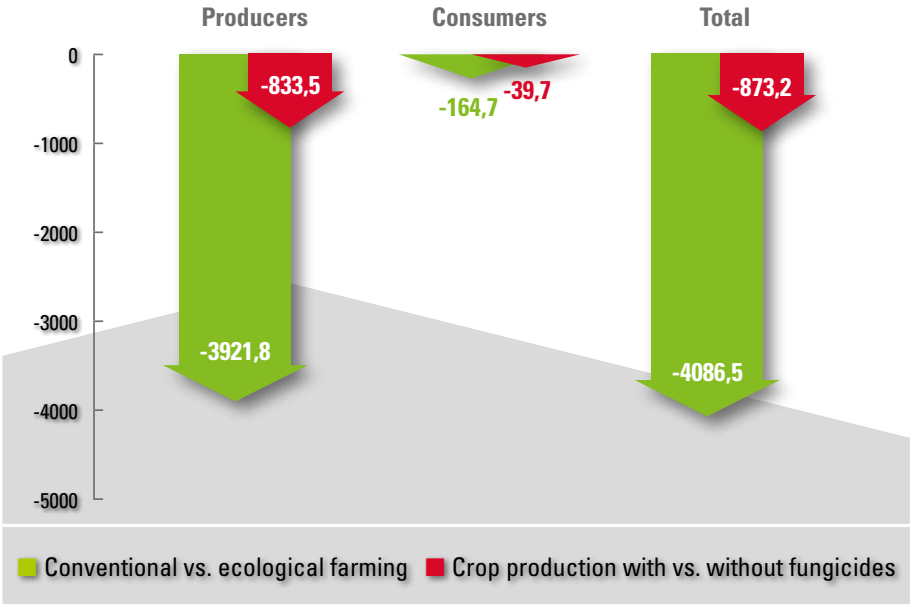
If Germany converts 100 % to ecological farming, 12 million tons of wheat are **missing** worldwide, equaling the annual wheat consumption of 184 million people.

If Germany converts 100 % to ecological farming, 5 million tons of potatoes are **missing** worldwide, equaling the annual potatoe consumption of 155 million people.

The effects of plant protection can also be defined and described as real economic effects. Plant protection enables producers to increase the supply for a certain market price, especially as plant protection reduces the average cost of the production of one ton of any agricultural commodity. Hence, farmers receive a benefit which, in applied welfare theory, is called 'producer surplus'. Consumers benefit from the market price signal caused by plant protection, too: They do not only buy cheaper, but also demand more quantities; thus, generating the so-called 'consumer surplus'. The total economic benefit for the society from the market exchange between consumers on the one side and producers (farmers) on the other side finally forms the sum of producer and consumer surplus, which is defined as 'social benefit'. Social benefits (respectively losses) can then be interpreted as an allegory for a positive (or negative) contribution to the gross domestic product.

Welfare losses due to ecological farming or abolishing fungicides in Germany would be extremely high. Without suitable plant protection, Germany lacks a social benefit of approximately 1 billion Euro (abolishing fungicides without substitution) to approximately 4 billion Euro (complete conversion to ecological farming). To compare: 4 billion Euro equal one third of the multi-year average of the net value-added in German agriculture, i.e. not only in arable farming, but in entire crop production and also animal husbandry. This emphasizes the huge economic impact modern plant protection has for the country.

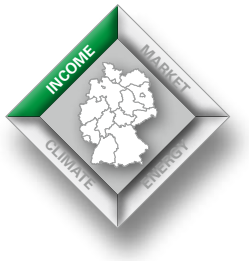
Welfare losses from abolishing plant protection (in million Euro)



The following conclusions can be drawn from the analysis of the market effects in the context of this project:

Plant protection is very important in Germany, which chiefly materializes in higher yields per hectare. Higher yields do increase the supply of agricultural commodities, and the higher supply decreases the market prices for agricultural produce. This creates considerable economic advantages both for producers of agricultural commodities and consumers of food and, more general, agricultural primary products. Thus, plant protection becomes a central factor of social welfare in Germany and is of extraordinary importance to the entire economy. Modern plant protection generates a social welfare of 1 to 4 billion Euro per year.

However, it is not only Germany who benefits. Higher yields from modern plant protection also secure the global supply of high quality food and feed as well as fuel and fiber which in turn contributes to food security, that is of increasing importance as a growing population and changing dietary habits are raising the worldwide agricultural demand in the years to come.



Higher income to farmers through plant protection in Germany

The society as a whole profits from the appropriate use of plant protection products in Germany. But how is this benefit mirrored in the income situation of typical farmers in the various regions of the country, considering a rather broad spectrum of farms in terms of size and specialization? This is the second central issue that shall be discussed within the overall project on the benefits of plant protection in Germany.

This study investigates the income effects of plant protection for ten typical farms, i.e. 'average' agricultural enterprises in a particular region and for a specific type of specialization. The farm accountancy data network of Germany provides respective data. The analysis covers in particular six arable farms. Five of them are family farms located in Mecklenburg-West Pomerania (1), Saxony-Anhalt (2), North Rhine-Westphalia (3), Lower Saxony (4), and Baden-Württemberg (5) and one of them is much larger and managed as a legal entity representing the region of Eastern Germany (6). The analysis is complemented by two family-managed livestock farms typical for Schleswig-Holstein (7) and Bavaria (8) and two mixed farms: a family farm in Hessen (9) and, again, a legal entity demonstrating agriculture in Eastern Germany (10). This ensures insights into a comprehensive and realistic spectrum of different farming systems in the country.

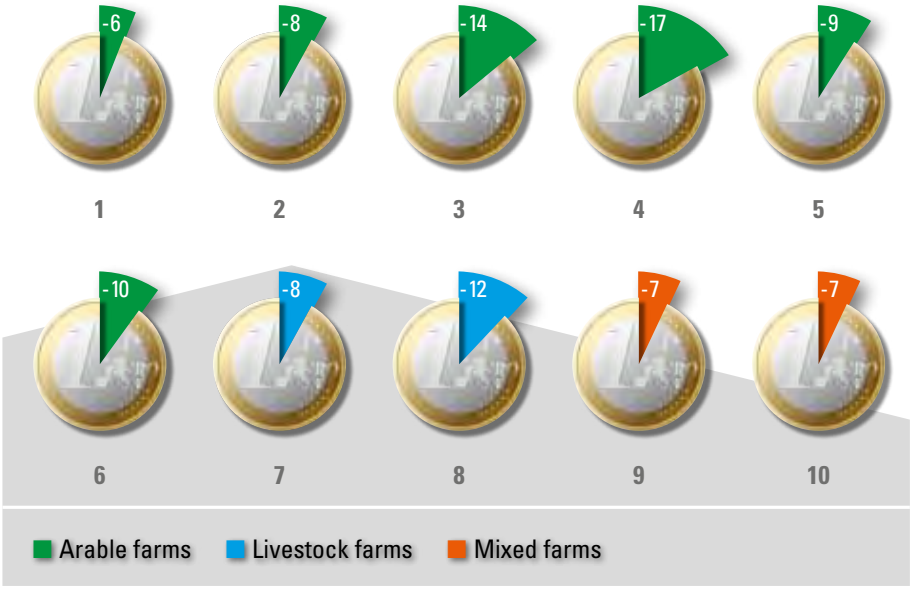
Target variables of the following analysis are two central indicators describing the income situation in agriculture, pre-defined by law and stipulated by the federal government's official agricultural reporting for statistical purposes.

- One is the calculated profit per hectare expressed in Euro/ha and resulting from the balance of revenues (including government transfer payments) on one side and the sum of variable direct cost and fixed cost on the other side.

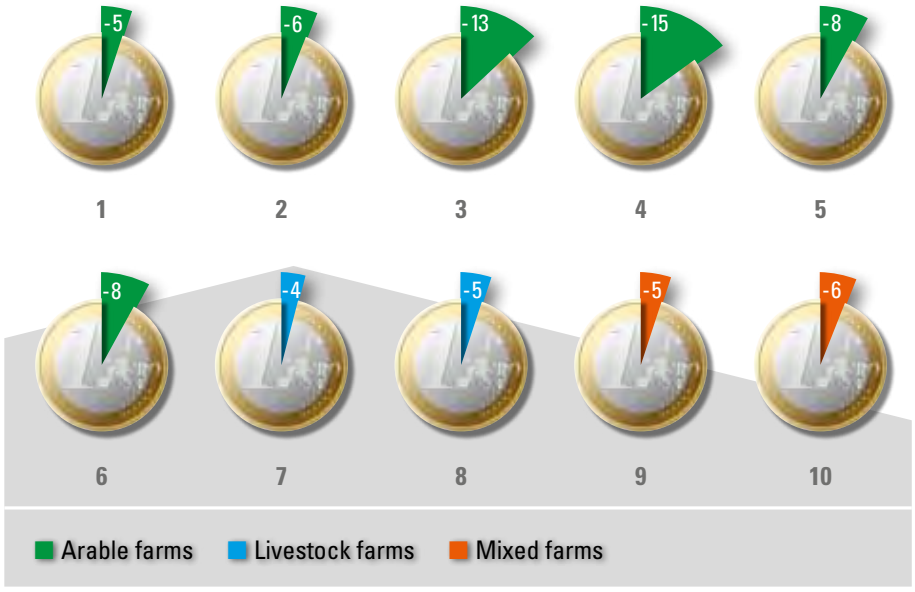
- The other one is the income per fully-employed annual working unit (AWU). This indicator is expressed in Euro/AWU (one AWU equals 1,800 working hours) and is computed by adding the calculated profit and the cost of labor for hired work force of a farm and relating this sum to the entire labor input of the respective farm.

If the yield and price effects resulting from the analysis of market effects are implemented in the above-mentioned standard procedures of revenue and cost accounting, real income effects of plant protection in Germany can be described and discussed on such base for the two scenarios defined.

- A comparison of 'crop production with vs. without fungicides' reveals considerable changes with respect to the calculated profit if a complete abolition of fungicides in Germany is assumed. The selected ten typical agricultural holdings would have to envisage a considerable decrease of profits. The decrease would amount to 6 to 17 % with both arable and livestock production suffering from losses.

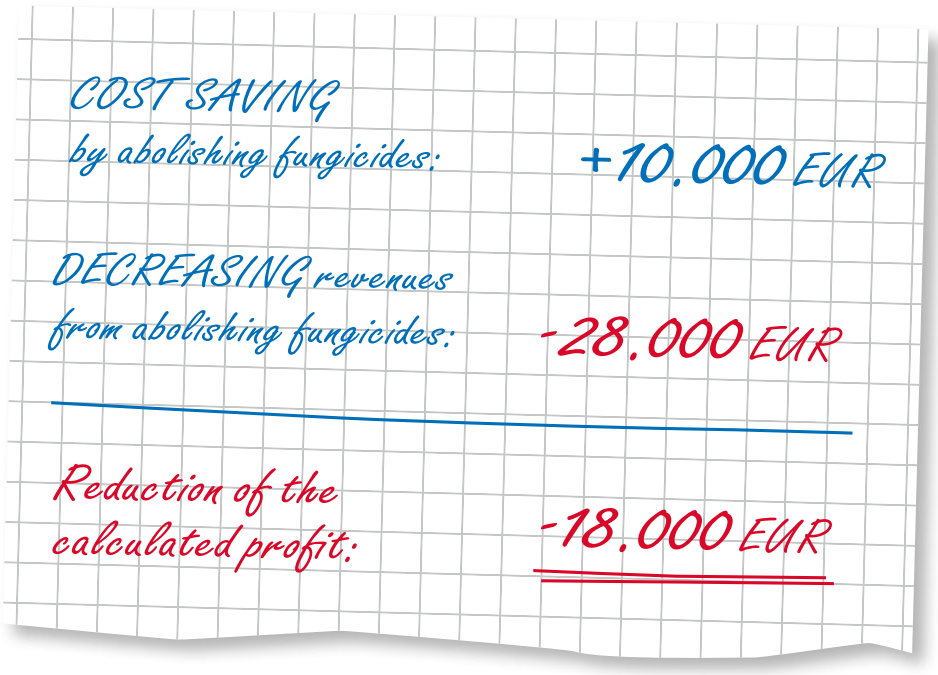


- Considerable changes can also be observed with respect to the income per fully employed AWU. The respective arable, livestock and mixed farms partly experience tremendous income losses. They can amount to up to 15 %. On average, all ten enterprises would suffer income losses equivalent to one 'monthly income' if no fungicides were available in German agriculture. In other words: The use of fungicides in Germany alone contributes considerably to a meaningful income of agricultural work force, i.e. of owners and employees of the agricultural holdings.



How can this be explained? Of course, on the one hand farms would save costs if fungicide applications were omitted and all other frame conditions remain unchanged. However, such cost savings would be over-compensated by a much larger decrease of revenues from product sales.
Less production simply means fewer market sales. The above characterized farm (4), e.g., is a 125 ha family-owned farm in Lower Saxony that would save approximately 10,000 EUR for purchasing and application of fungicides. However, revenues would decrease by 28,000 EUR. Thus, the calculated profit would decrease by 18,000 EUR in total.

Example: Typical farm (4):
A 125 ha farm in Lower Saxony



More distinctive than the analysis of the scenario 'crop production with vs. without fungicides' is the analysis of the scenario 'conventional vs. ecological farming' as income effects from converting to ecological farming are not exclusively derived from achievable market income. Ecological farms rather receive higher politically motivated transfer payments which need to be considered in the respective income calculations as well.

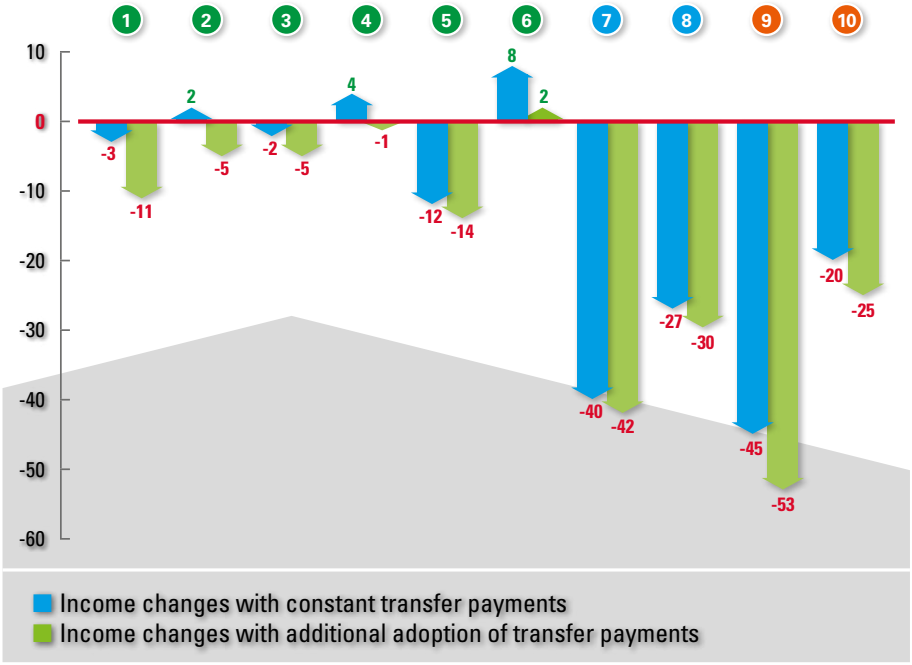
Despite these additional transfers, in seven of the ten selected typical farms a conversion from conventional to ecological farming would result in—partly even substantial—negative income effects. Farm (5), e.g., an arable family farm in Baden-Württemberg, would experience an income loss of 12 %. On the other hand, the income situation slightly improves for three of the selected arable farms.

However, this is merely an interim conclusion of the income situation analysis for the scenario 'conventional vs. ecological farming'. Taking into account (beyond market effects) that policy-motivated transfer payments would also have to decrease as the result of an overall conversion to ecological farming (assuming a cap of the current transfer amount for all Germany on today's level), all selected agricultural holdings, except farm (6), would experience negative changes of the generated agricultural income and would be unable to survive on the long run.

Livestock farms, at which a sufficient market income in ecological crop production compensates for systematic losses in animal husbandry up till now, would be most severely hit.

If more ecological farms entered this market segment, the positive impact on income would disappear or not be that distinctive.

Importance of policy-motivated transfer payments for converting to ecological farming



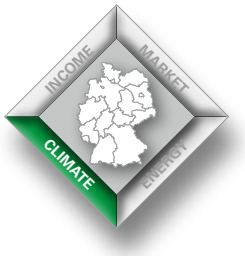
On income effects, the following can be said:

Plant protection significantly contributes to the income of agricultural holdings, i.e. of their employees and owners in Germany. Abolishing fungicides in crop production in Germany would cause a drastic decline in income, on average equaling a monthly salary, but can be even more severe with specific farming systems. Thus, fungicides, i.e. inputs that normally account for only limited costs in agricultural production, do have a huge financial leverage and contribute high income potentials for farms.

Just a few farms would benefit slightly from converting to ecological farming as not only the market but also the political support system would certainly change. If at all, positive income effects from converting to ecological farming would have to be attributed to policy-motivated transfer payments and not to additional market income.

Altogether this means that plant protection ensures the economic viability and competitiveness of agricultural holdings in Germany and, thus, the income of agricultural employees and farm-owners. This makes plant protection a major determinant for our various structures in rural areas. These structures define the country's cultivated landscape, and its diversity in itself constitutes added value which must not be overlooked.

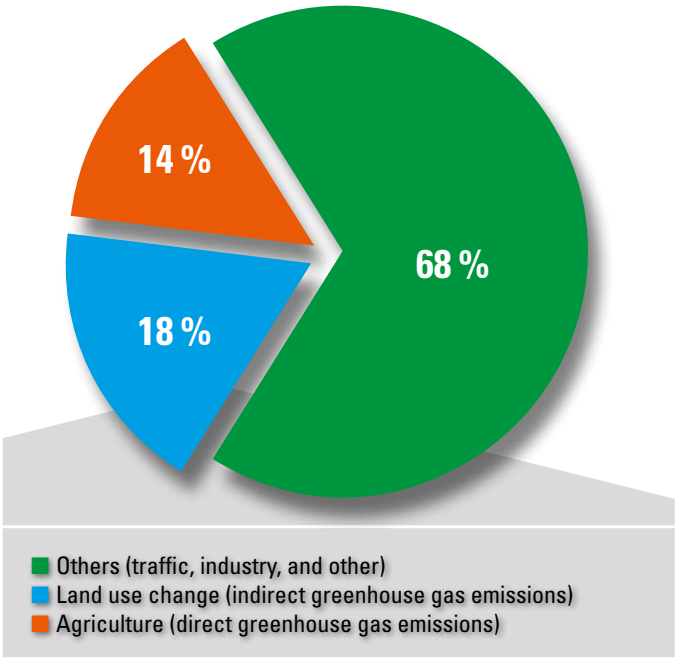
Positive climate effects through modern plant protection management



Globally, agricultural production processes account for considerable emissions of greenhouse gases. However, modern agricultural production techniques can reduce these emissions substantially. Plant protection plays an important role in decreasing the emissions per unit of agricultural commodity produced. This is to be elaborated further.

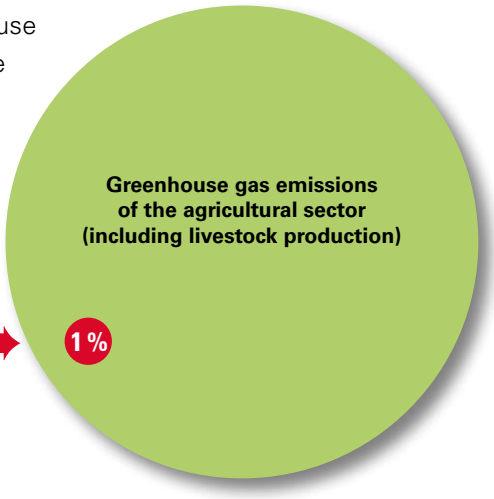
Direct greenhouse gas emissions from agriculture account for approximately 11 % of all emissions in Germany. Globally, estimates attribute one third of all direct and so-called indirect greenhouse gas emissions to agricultural production.

When analyzing direct greenhouse gas emissions in Germany one finds that the prime source for emissions is animal husbandry and not crop production. Within crop production, certain greenhouse gas emissions are attributable to plant protection, in particular during the production process, but also during transportation and application of the products. However, the total is very small: All plant protection-related emissions of climate gasses contribute to approximately 1 % of the total agricultural greenhouse gas emissions of the country.



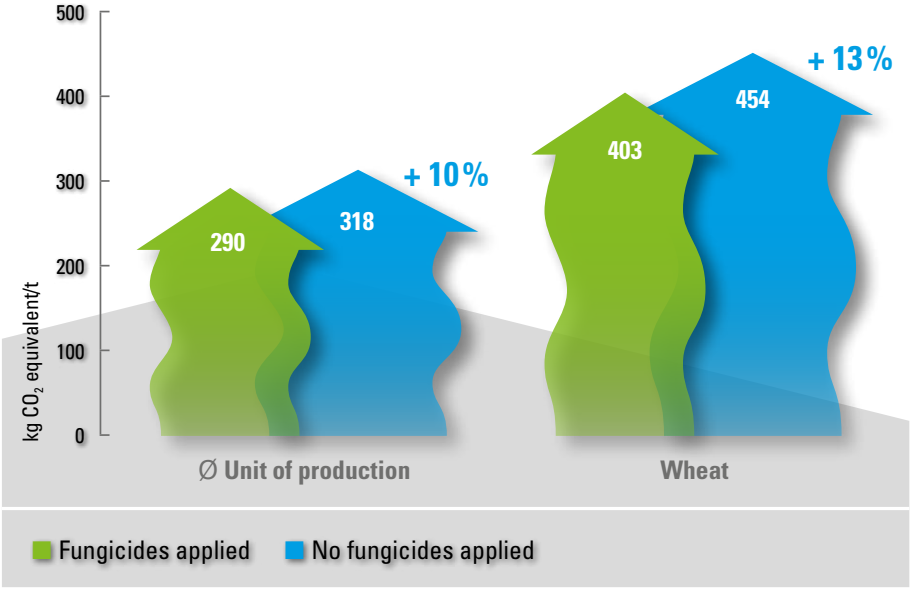
Global greenhouse gas emissions, based on Stern 2007

Share of greenhouse gas emissions caused by plant protection of emissions of agriculture in Germany



Without plant protection and the respective, yet relatively low greenhouse gas emissions, the specific emissions per unit of production in German agriculture would be much higher, the main reason being that yield decreases due to plant protection weigh much higher than small savings due to omitted plant protection on the field.

Greenhouse gas emissions per unit of production in German arable farming with and without fungicides

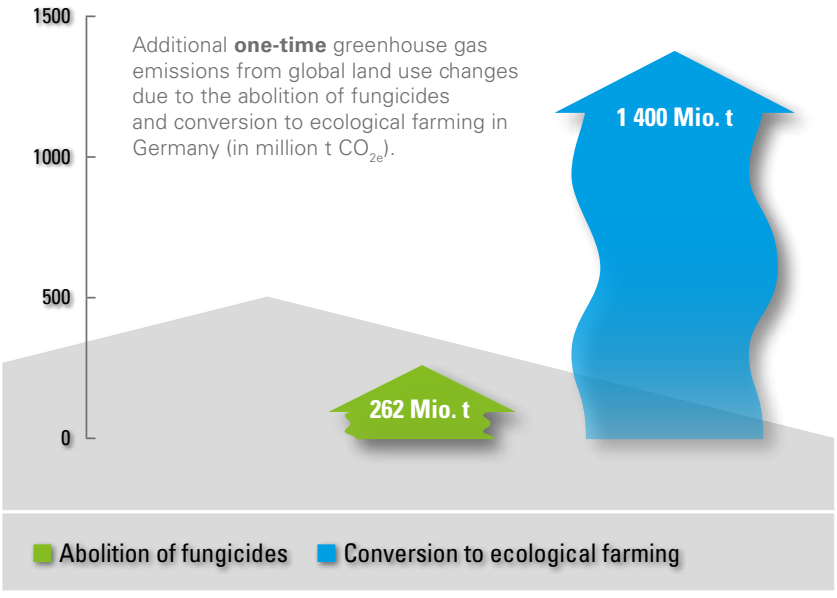


For example: If no fungicides were available to farmers, greenhouse gas emission attributable to the production of one ton of wheat would rise from 400 to 450 kg CO_2 equivalents per ton, equivalent to an increase by 13 % per unit of production. In average, crop production would emit at least 10 % more GHG per unit of production if fungicides were neither available as agricultural input nor substituted adequately.

However, indirect greenhouse gas emissions play a far more important role than direct greenhouse gas emissions from agriculture. As demand on international agricultural markets is predicted to grow in future years and decades, production losses in Germany — regardless if related to a mere lack of fungicides or the conversion to ecological farming — would stimulate increased agricultural production in other parts of the globe. In other words: Other regions of the world would have to intensify production, and from a global perspective more land would be cultivated for agriculture in total.

- More intensive agricultural production elsewhere will result in additional and higher greenhouse gas emissions there. Emissions omitted here will just be exported or re-allocated. The prompted increase in greenhouse gas emissions in other, and likely less efficient agricultural systems, will outweigh a potential decrease in Germany, where strict environmental standards apply and modern environmentally sound technologies are used in conventional agriculture.

- This greenhouse gas effect, which is hard to calculate, is exceeded by climate effects caused by land use changes called 'indirect land use change' (ILUC). It becomes evident in the clearance of rain forest and the cultivation of savannahs, etc. Such ILUC brings about tremendous emissions of CO_2 as carbon previously sequestered in above- or below-ground biomass in natural or nature-like vegetation systems is no longer fixed but emitted as a climate gas.



The impact of the ILUC effect, which is based on changing technological framework conditions, on the greenhouse gas balance of agricultural production can be calculated.

In order to compensate the production loss in Germany in the scenario 'crop production with vs. without fungicides' on the world market as analyzed above, approximately 1.2 million ha arable land from previously non-agricultural use would have to be additionally cultivated outside the country. And with converting 20 % of Germany's agricultural land to ecological farming, it would even be more, namely 1.3 million ha. Last but not least: A complete conversion from conventional to ecological farming would 'cost' 6.5 million ha natural habitats that would have to be additionally cultivated globally for harvesting arable crops. This equals half the arable land in Germany.

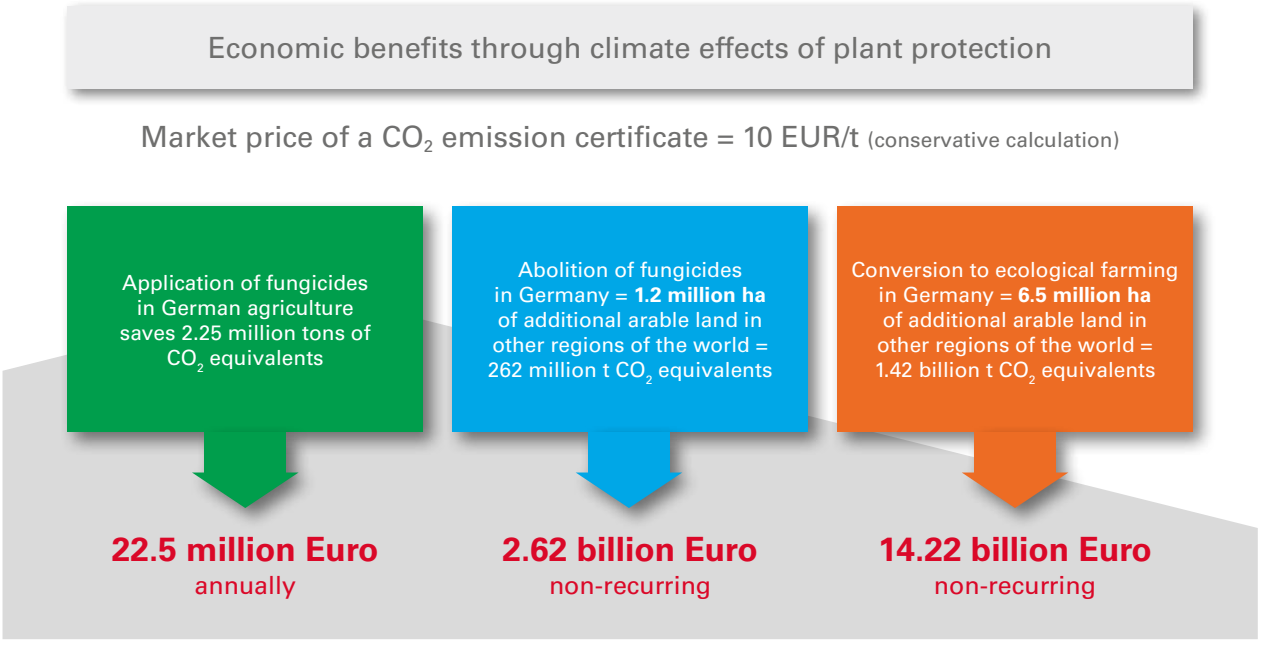
Using scientific data on the regional distribution of the arable land that would have to be additionally cultivated worldwide and, in addition, information on the amount of carbon per eco-system still sequestered in the individual eco-systems and regions of the world, it is possible to determine the additional amount of CO_2 that would be emitted if we partially or completely abolished modern plant protection.

In the scenario 'crop production with vs. without fungicides' more than 260 million tons of CO_2 equivalents would additionally be emitted; with a partial conversion of arable land (20 %) to ecological farming, it would by 280 million tons; and with a complete conversion in the scenario 'conventional vs. ecological farming' even 1,400 million tons of CO_2 equivalents would be released to the atmosphere.

For comparison: Currently, Germany emits just below 1 billion tons of CO_2 equivalents each year.

The amounts of direct greenhouse gases from partly or completely abolishing plant protection mentioned above would be emitted every year, whereas indirect greenhouse gas emissions would be a one-time effect. Despite these different time horizons, the described climate effects can be defined monetarily, namely if the CO_2 emission potential of a (partial) abolition of plant protection is valued at market prices of CO_2 certificates. Considering a fully functioning market for such certificates, the study assumes a market price of 10 Euro per ton of CO_2, which rather marks the minimum level of currently available prognoses for this price under a liberalized trade regime.

In such a case, modern plant protection, in the form of fungicides, saves 22.5 million Euro climate costs per year, because direct greenhouse gas emissions are prevented. In addition, the scenario 'crop production with vs. without fungicides' saves 2.6 billion Euro once as the global cultivation of non-agricultural land with related greenhouse gas emissions can also be prevented. The scenario 'conventional vs. ecological farming' would even reveal respective welfare losses amounting to 14.2 billion Euro, namely if farming was completely converted to ecological farming and production was relocated to other land outside Germany. These effects are accordingly smaller with a partial, e.g. 20 %, conversion from conventional to ecological farming.



In addition to reducing greenhouse gas emissions, plant protection plays another important role in coping with climate change: It helps to mitigate the adaptation pressure that agriculture faces. Higher greenhouse gas concentrations in the atmosphere, higher average temperatures and changing water availability, along with climate-related extreme weather and soil erosion, present major challenges for agriculture.

Plant protection, not only as a yield increasing but mainly a yield securing factor in crop production, will substantially contribute by securing harvests and a sufficient food availability, when agriculture will be forced to adapt to climate change.

The following conclusion can be drawn on climate effects of plant protection:

Plant protection is an essential component in meeting the global challenge of climate change. It facilitates the adaptation process of agriculture to the changing frame conditions. Plant protection itself causes very few greenhouse gas emissions, but contributes to a better and positive climate balance of the sector by increasing and securing yields per ha of land.

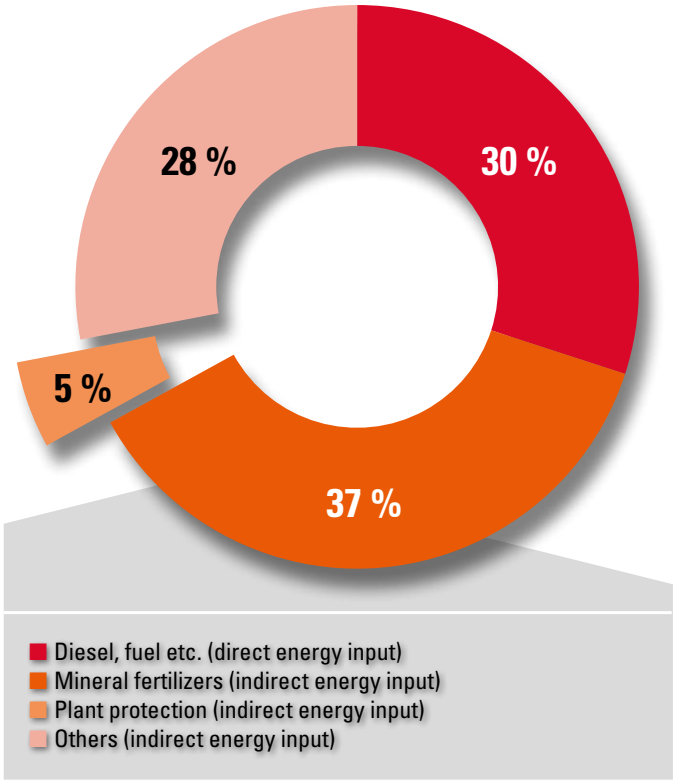
Consequently, modern plant protection becomes an important part, not only of economic but also of environmental sustainability. It assures that a scarce resource – arable land – is used efficiently, which in turn helps protecting natural habitats and the climate.

A functioning emission trade, including agriculture, is able to generate a potential economic surplus that can be extremely high. This enhances economic sustainability in addition to what has already been described in the analyses of market and income effects above.

Positive energy balances and high energy efficiency through plant protection

Unlike other sectors of the economy, agriculture in Germany is generally energy-extensive, i.e. the agricultural sector proportionally consumes less energy than it contributes economically to the gross domestic product. Most significant determinants of energy consumption in crop production are mineral fertilizers, fuel and lubricants, and the use of agricultural machinery. However, the impact of plant protection on the energy use in agriculture in Germany is very low and only accounts for 1 to 2 % of the total energy demand of entire agriculture respectively 5 % of the energy use in arable farming.

Direct and indirect energy inputs in agriculture and the importance of plant protection for the use of energy



In crop production and particularly in arable farming substantially more solar energy is stored in organic matter respectively biomass than used from fossil energy and other sources of energy. Energy productivity in arable farming is, thus, generally very high. This applies both to conventional and ecological farming systems. Relatively energy-intensive inputs of agricultural production processes, such as fertilizers and plant protection help maximize the conversion of solar energy into usable biomass.

As obvious as this correlation is, as complex is the analysis of energy balances and energy efficiency in arable farming. It is very important for the understanding of the findings to select correct, i.e. suitable, indicators that are scientifically well-accepted. Against this background, key data for the assessment of this study comprise energy gain, i.e. the difference between energy yield (energy output) and energy use (energy input) per hectare, energy productivity, i.e. the ratio of energy output to energy input, and finally energy intensity – in other words: the energy input per unit of product. The energy input per unit of area, i.e. a figure that is commonly used to mirror the energetic advantage of ecological farming, is no suitable indicator for the assessment of energy efficiency in agriculture.

The data base for calculating meaningful indicators shows major uncertainties: Many specific energy contents of individual agricultural inputs are not clear, and too often rather broad estimates exist pointing at the specific energy demand in the production of inputs such as fertilizers etc. Hence, the general dilemma is the resulting uncertainty and the only option is to base the necessary analysis on many assumptions. However, this uncertainty of allocating energy can be reduced for crop production in Germany if the analysis driven by new scientific findings and technology developments in practice, as done in this study.

Against this background, the calculated energy efficiency in conventional arable farming in Germany can generally be considered high.

Agricultural crops fix the tenfold amount of solar energy than spent in form of applying inputs to achieve this effect. The calculated average net energy gain is much higher than 100 GJ/ha of arable land. Although the individual crops show significant differences, e.g. with sugar beet it is more than 200 GJ/ha because of the high energy density of the crop, the general principle of high energy efficiency of agriculture in Germany remains untouched by these differences.

In the scenario ‘crop production with vs. without fungicides’, energy input in German agriculture would be reduced only insignificantly when not using plant protection, namely by only 2 %. However, the resulting energy loss on the output side would be much higher. It would amount on average to almost 10 % due to decreased yields per unit of arable land. This would on the one hand drastically reduce the energy gain and energy productivity, and energy intensity in arable farming on the other hand would partly increase considerably.

Without fungicides, German agriculture would alternatively have to spend an additional energy input of almost 10 million GJ if production losses from yield decreases had to be compensated within the country. However, such scenario implies the availability of more land in Germany. This is no real option. Instead it is necessary to be aware that biomass and the energy fixed in it would be lost in Germany without fungicides.

The potential loss can be defined as follows: More than 90 million GJ of usable energy in form of food and agricultural biomass for other uses would be lacking. This equals 25 % of the electric power produced in the nuclear power plants of Germany operated in the year 2012 or the energy content of over 3 million tons of black coal or over 2 million tons of crude oil.

Energy content of additionally produced agricultural biomass with fungicide application compared to other energy sources

1/4 of the annual production of all German nuclear power plants (almost 100 TWh)

3.08 million tons of black coal

2.15 million tons of crude oil

Significant energy losses through conversion to ecological farming

The amount of energy that would no longer be available when fully converting to ecological farming equals one third of the current German black coal imports.

A conversion to ecological farming would have serious consequences. As several recent research studies have revealed before, the scenario 'conventional vs. ecological farming' confirmed once again that ecological farming presents no advantages in terms of energy efficiency compared to conventional farming. Energy productivity and energy intensity do change only slightly with a conversion to ecological farming, what neither hints at advantages nor disadvantages of the respective farming system; however, the loss in energy gain due to conversion is huge.

With a 20 % conversion, almost 10 % of energy stored in agricultural biomass would be lost, with a complete conversion to ecological farming even 50 %. This amount equals 400 million GJ and is bigger than the annual production of all remaining German nuclear power plants in 2012 or as high as the energy content of 13 million tons of black coal or almost 10 million tons of crude oil. For comparison: 13 million tons of black coal equal one third of the country's import demand or are more than Germany's current domestic extraction of black coal; 10 million tons of crude oil equal approximately 10 % of the respective import demand.

The calculated change values of the energy efficiency and energy balance due to deviations from modern plant protection as applied in Germany are again rather conservative calculations, as, given above-mentioned uncertainties, the conventions of the analysis are generally based on assumptions that presuppose an underestimation of the positive effects of plant protection.

Finally, the discussion of the energy effects requires, just like the discussion of the climate effects, to hint at re-allocation effects. Without reasonable plant protection in Germany, production would shift to regions of the world, where the energy efficiency of agriculture is generally lower. Hence, possible savings of energy consumption here would be bought at a much higher price in terms of energy use in other countries of the world.

Also for energy effects a separate conclusion can be drawn:

Energy is a basic requirement for agriculture. Without proper energy input it would not be possible to gain a multiple of solar energy converted to biomass and make it available for the various uses with regard to agricultural raw materials. Plant protection increases this energy gain and is, moreover, an essential determinant for the agricultural sector being one of the most energy efficient branches of an economy. Apart from this general statement, the energy advantages are even more distinct in conventional than in ecological farming.

If individual options of plant protection were partially or even completely removed from the portfolio of management options of farmers in Germany, serious consequences would thus be the result: If potential net energy losses as in agriculture were the same in the German energy sector, they would possibly cause considerable changes and jeopardize the stability and sustainability of our energy supply system.

Summary of the study and an invitation to a dialogue

In sharp contrast to the common public opinion, chemical-synthetic plant protection accounts for many positive effects on the society at large. The IVA-initiated project 'Social benefits of plant protection in Germany' investigates the assumption that macroeconomic development and social welfare, mitigation of climate change and increasing food security, protection of natural resources and environmental protection will be no trade-offs but offer synergies if plant protection is done target-oriented and if plant protective agents are properly applied on-farm. This hypothesis could be confirmed with numerous facts. Hence, it can be stated that plant protection contributes to at least ten social benefit targets that have been concluded for Germany, but might be generally applicable:

1 Plant protection secures and increases yields per unit of arable land and thus, contributes significantly to higher productivity in agriculture.

2 Higher yields per unit of arable land increase the supply of primary agricultural products on international markets, making plant protection indispensable for reaching the millennium goal on hunger and malnutrition and an improved world food security situation.

3 Plant protection contributes to a higher economic prosperity and particularly increases a nation's gross domestic product; the entire agricultural value chain up to the final consumer will profit.

4 Above all, modern plant protection ensures and notably increases the income of farmers and agricultural employees. Possible higher costs due to plant protection are clearly overcompensated by much more rising revenues and returns in investment.

5 Thus, an important contribution to maintaining not only economically viable but also socially balanced and environmentally sustainable agricultural structures in rural areas is made.

6 In fact, plant protection does not only bring about positive economic effects, but also generates substantial environmental effects. It helps save the globally scarce resource of arable land or soil through generating higher yields per unit of area.

7 If less land is needed to meet the growing demand for food and agricultural raw materials today and in the future by applying modern plant protection, existing natural and nature-like habitats are secured and thus, global biodiversity is saved.

8 Besides, a considerable contribution is made to meet the challenges of climate change. Plant protection not only emits few greenhouse gasses, it also secures that less CO_2 is emitted as it helps to avoid negative land use change, i.e. plant protection has an important mitigation effect.

9 Along with mitigation, also adaptation is a big challenge with regard to climate change: Plant protection facilitates this adaptation as climate-caused new risks like migrating pests and diseases can be effectively controlled, and more stable yields in uncertain times mean a higher degree of insurance for farmers and the overall society.

10 The energy balance of plant protection is also positive. One may conclude: Plant protection requires little energy, but brings about a huge energy gain. This causes high energy productivity and low energy intensity, what makes the agricultural sector a comparably energy-efficient branch of the national economy.

The project has made an essential contribution that needs to be considered in the future discussion on social benefits of plant protection. All stakeholders are invited to consider these facts and findings in the further discussion. The presented results are expected to provide important information that will facilitate an objective public debate on real benefits and costs of plant protection.

Of course, the results of this study are not carved in stone and should be reflected for other than the described crops and regions. The authors commit themselves to further reflect on the issue. It is expected that the rather conservative statements and concluded results can be confirmed. The intensive public dialogue that focuses rather on scientific facts than emotional arguments, that compares real opportunities with perceived risks and thus, offers a better base for private investment and political decisions is open.

Acknowledgement

Within the project ‘Social benefits of plant protection in Germany’, four studies* were carried out. The project and the studies were initiated and partly financed by Industrieverband Agrar e.V. (IVA). We appreciate the support of IVA during the entire project period and the four studies. Special thanks go to the members of the steering committee ‘benefits of plant protection’ at IVA for target-oriented and open-minded discussions as well as numerous valuable hints during the duration of the project. However, the authors alone are responsible for the results and the statements in this study, which were by no means influenced by the initiator of the project.

(*) The four individual studies (in German language) are available for download at:
http://www.agrar.hu-berlin.de/fakultaet/departments/daoe/ihe/Veroeff

1 von Witzke, H.; Noleppa, S. (2011): Der gesamtgesellschaftliche Nutzen von Pflanzenschutz in Deutschland. Darstellung des Projektansatzes und von Ergebnissen zu Modul 1: Ermittlung von Markteffekten und gesamtwirtschaftlicher Bedeutung. Berlin: agripol GbR und Humboldt-Universität zu Berlin.

2 Noleppa, S.; von Witzke, H.; Cartsburg, M. (2012): Einkommenseffekte des Einsatzes von Pflanzenschutzmitteln in Deutschland. Darstellung der Ergebnisse zum Modul „Einkommenseffekte“ des Projektes zum gesamtgesellschaftlichen Nutzen des Pflanzenschutzes in Deutschland. Berlin: agripol GbR und Humboldt-Universität zu Berlin.

3 von Witzke, H.; Noleppa, S. (2012): Klimaeffekte des Pflanzenschutzes in Deutschland. Darstellung von Ergebnissen zum Modul „Klimaeffekte“ des Projektes zum gesamtgesellschaftlichen Nutzen des Pflanzenschutzes in Deutschland. Berlin: agripol GbR und Humboldt-Universität zu Berlin.

4 Noleppa, S.; von Witzke, H. (2013): Energieeffizienz durch den Einsatz von Pflanzenschutzmitteln in Deutschland. Darstellung der Ergebnisse zum Modul „Energieeffekte“ des Projektes zum gesamtgesellschaftlichen Nutzen des Pflanzenschutzes in Deutschland. Berlin: agripol GbR und Humboldt-Universität zu Berlin.

Further information available at:

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