Subject

Economics

Title

Impact of pesticides and their decline in usage

Question

To what extent is the German government's intervention in pesticides accomplishing sustainability as part of a green future?

Word count

3603

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Introduction

The concept use of Pesticides being a substance meant to control pests in agriculture had been around for centuries, but the introduction of chemical pesticides after World War II saw extreme benefits like the improved yield of clean-looking agricultural products. This was an issue as consumers had a bias against stained-patchy fruit which had farmers cutting out fruit that wasn't perfect out of their harvest, resulting in a lower supply in the market which caused raised prices. The benefits extended past the increased yield of products as farmers lowered prices due to better yield. This made the agricultural industry become more competitive as demand increased from a surplus of products. Hunger from the low-income population could be better addressed and handled as food became more affordable as well. Annually 20-40% of crop production is lost to weeds, pests, and diseases (Bayer 2022), without the presence of pesticides this value could double increasing prices and making food less available affecting every consumer, especially lower-income ones.

The immense benefits however could not overshadow how pesticides negatively affected the environment and humans. It was discovered that there are short-term and long-term effects of being exposed to pesticides on humans. The short-term effects or acute effects are stinging eyes, rashes, blisters, blindness, nausea, dizziness, diarrhea, and death according to EPA (Environmental protection agency, 2021). Long-term or chronic effects were birth defects, cancer, and neurological and developmental toxicity(ibid.,2021). These effects lead to increased health care costs for example as more people are being treated when encountering certain pesticides. The environment arguably was impacted far worse as pesticides uninhabited many insects and animals as their environment became toxic to them. Livestock farming uses 78% of the available agricultural land in the world (destatis, 2021), with the increase in demand for land it’s rapidly destroying the environment. Pesticides are further contributing to the problem of destroying natural habitats in the environment.

The European green deal signed on July 1st, 2020, made it a goal for Europe to be the first climate-neutral continent by 2050. The green deal aims to create a cleaner environment, produce cleaner

energy and improve the overall quality of life. A part of the goal called the EU Chemicals Strategy for Sustainability involves innovation for safe and sustainable chemicals as well as prohibiting certain chemicals in production. The strategy wants to ensure that the most dangerous chemicals compromising human health and the environment are avoided in production. With some of the top countries in agriculture output like the Netherlands, Germany, and France being European countries this deal affects the economic output of these counties as it will limit what can be used in the production of the goods they produce. This will lead to a focus on its impact on the environment and how prominent it is.

I think that as the progression of climate/environmentally safe practices develops it will cause existing practices that are not sustainable to become futile. Their futility and diminishing usefulness will result in the adoption of these new safer practices. On paper removing bad chemicals like pesticides sound good and is the only option to do. I want to find out to what extent are the impacts justifiable and are seen as progressively growing.

I chose this topic because my parents work for BASF, and I remember when I was younger being taught in school that pesticides had caused bald eagles to become endangered because they caused birth effects. I expressed my innocent anger towards pesticides not realizing that pesticides were a part of my parent’s jobs and how they got paid. Back then I thought anyone involved in pesticides was a bad person, but I didn't understand the jobs created by pesticides.

When thinking of a topic I remembered this and did some research to see what's being done to diminish pesticide use and I found out about the European green deal and its objectives. With the European green deal making it a goal for Europe to be climate neutral it made me question its impact on the usage of pesticides and sales and how justified are the actions based on its impact, hence why I'm choosing this topic.

Methodology

When researching I wanted to make sure that I identified the most prominent pesticides in Germany by looking at sales over the years for pesticides in total and the individual sales by type. I'm doing this to see if Germany is targeting pesticides on a broader scale or rather specifically targeting the most detrimental types of pesticides to the environment

I will gather primary information by surveying farmers who are involved with the usage of pesticides and get feedback on how they feel working with the chemicals and if they know anyone who has been negatively affected. I will also gather information on the reasons for using pesticides which I will connect to determinants of usage. My focus will be on seeing how the German government can help address the problems that can arise once pesticides are restricted.

I also gathered secondary information on the substances detected in passive air samples. This is to highlight and demonstrate the presence of pesticides in areas and how they can go undetected. The air samples show hot zones where certain pesticides are more prevalent and how it results in a higher amount appearing in samples. I would like to demonstrate how a decrease in pesticide usage would result in less detectable substances in the air we breathe.

Since firms will not be able to produce certain chemicals in hopes to become climate neutral in accordance with government bans this means that certain products will no longer be available. Theoretically then this means the firm's total revenue will decrease because they can no longer sell certain products which will result in many actions needing to be taken. Firms will have to look at raising prices to cover losses in total revenue so that they do not lose out on normal profits. Firms may consider firing workers to make up for the loss in revenue. Since pesticides are a negative externality and are being supplied at quantity over the social optimum consumption would return to a level where there would be no welfare loss. Firms will also have to spend more on advertising and company

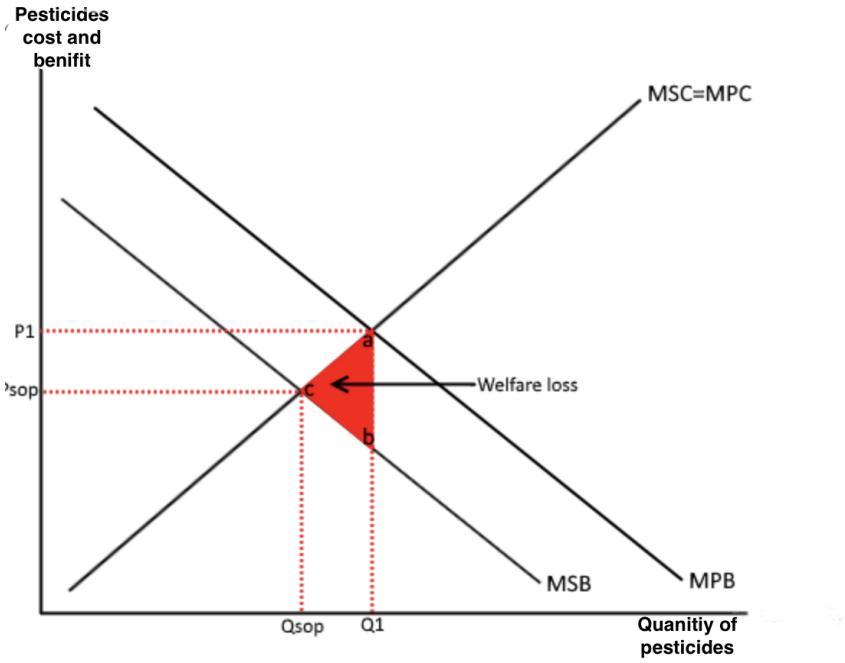
image as they will have to diminish the view that they once sold pesticides and other harmful chemicals and convince consumers that they are doing lots of actions to aid in a climate-neutral continent. Regarding sales of pesticides, there should be a clear difference in sales with the progression of climate-neutral activities. There is a possibility that a clear difference will not be spotted as Germany has had difficulties progressively getting stricter and reducing pesticide usage. This would then result in possible stagnant sales that would show that Germany has not done nearly enough to have a clear impact on usage and sales. The case can be made that until a proven-effective alternative is released the market is unable to shift to an absence of pesticides.

Theory

Market failure: Negative externalities of Pesticides

Market failure happens in the consumption of pesticides and other chemicals in Germany as there are negative externalities of consumption. Looking at figure 1 overconsumption occurs as private benefits (PMB) are greater than social benefits (SMB) which causes the negative externality and also welfare loss (red triangle) in this case impacts on consumer health and the environment. Pesticides and other harmful chemicals are also demerited goods as they create effects that are deemed detrimental to society and overall well-being.

Figure 1: Negative externalities of consumption for harmful pesticides

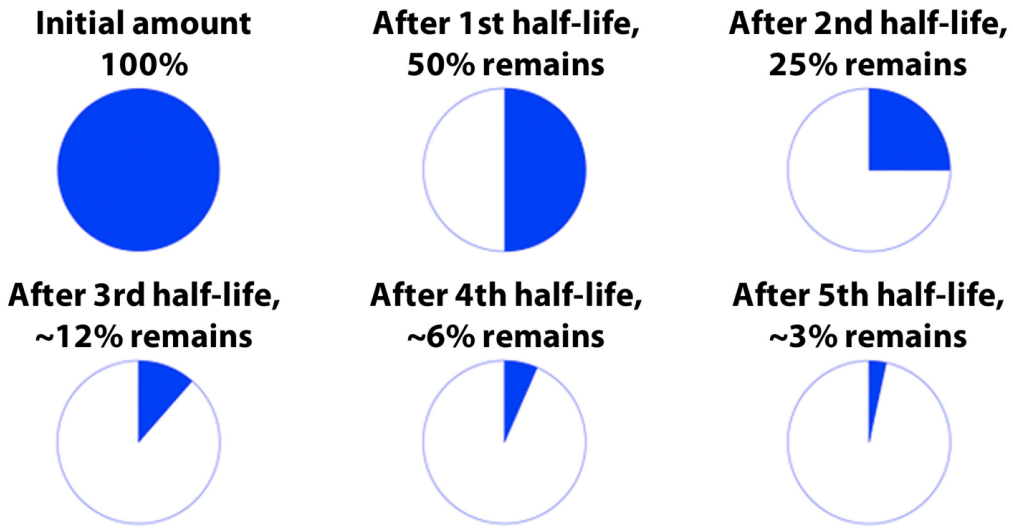


(Adapted from Edexcel Economics revision)

Referring to figure 1 again the welfare loss is representative of society losing in this situation it would be the impacts on health and the environment. Since these pesticides are negative externalities, as mentioned in the introduction pesticides can cause long-lasting effects like cancer, birth defects, and developmental issues or abnormality conditions in children(beyondpesticide.org).

These negative conditions that can develop lead to an annual of 200,000 deaths worldwide (UN report). These deaths are the result of contamination from the pesticides and the most frequent cases are from the workers spraying the chemicals. They are negatively affected which causes production to slow as workers are getting sick and hesitation happens to use pesticides because of how dangerous they are to humans after long exposure.

Figure 2: Half-life of pesticides



(National Pesticide Information Center, 2015)

Pesticides are split into three groups for how long they can last in the environment. Low (less than 16 days), moderate (16 to 59days) and high (over 60 days) and vary on pesticide(Ibid.,2015). Pesticides with longer half-lives tend to last longer and the environment and therefore build up at greater rates. This increases the likelihood of them leaking into the environment and other sources they are not intended to encounter. This is seen in figure 3.

Sustainability: Environmental damage

Pesticides compromise the sustainability of the areas they are used in because they run off from the treated plants and soil into the water sources like the groundwater and rivers depicted. The leakage is shown in figure 3 where the application has many ways to unintentionally end up elsewhere creating the externalities of consumption as the environment is negatively affected as a result of usage.

Figure 3: Ways pesticides enter the environment and endure for long periods of time

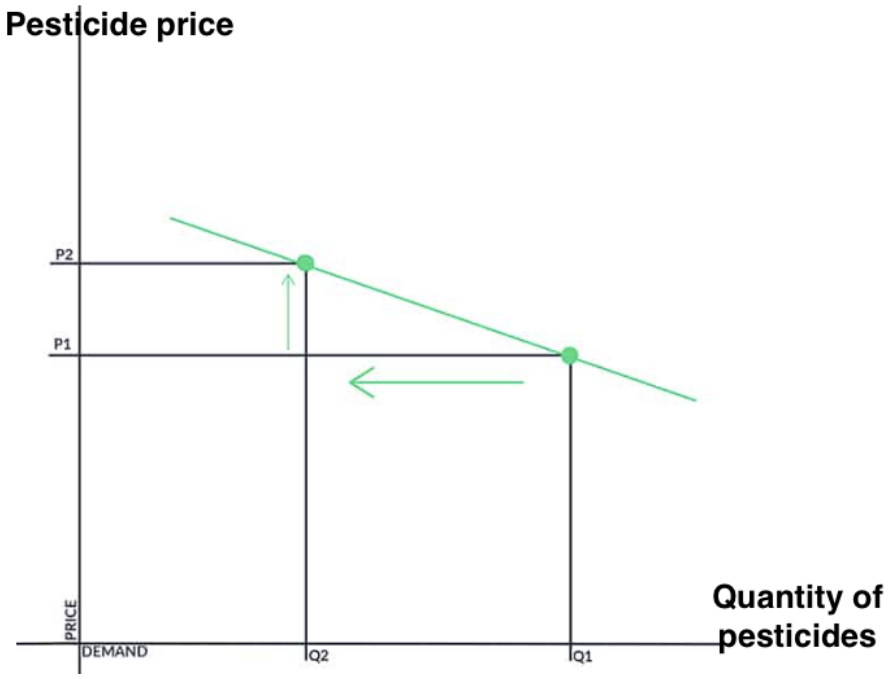
(www.agro.basf.com)

Referring to figure 3 above, pesticides cause so much harm and threaten sustainability because of how easily they can be transported into an environment. Pesticides hurt insects as the soil absorbs the harmful chemicals and kills them. If the insects don't die, they carry the deadly chemicals on them which end up in animals as they eat the insects which then leads to animals dying, having birth defects, and the chemicals being transmitted even further. An extreme example of birth defects was the decline of bald eagles in the U.S as a result of exposure to the chemical DDT(Dichlorodiphenyltrichloroethane). The consumption of insects contaminated with DDT resulted in eggshell thinning for bald eagles (EPA, 2022). This decline in population resulted in the U.S government banning the substance in 1972 which resulted in the bald eagle population recovering.

Substitutes to pesticides

Since pesticides are incredibly harmful to the environment, alternatives have been found and created to be better options. These alternatives can be called substitutes which would make the demand for pesticides elastic. Substitutes for pesticides can be called “Soft chemicals" and are pesticides that come from natural sources. These natural sources are usually “plants, as is the case with pyrethrum (pyrethrins), rotenone or ryania (botanical insecticides), or minerals, such as boric acid, cryolite, or diatomaceous earth” (Clemson EDU). These substitutes make pesticides obsolete as they can perform the same task but more sustainably.

Figure 4: Substitutes causing elasticity in pesticides



(Prisync.com, 2018)

Referring to figure 4 since the closeness of substitutes is rising it results in pesticide demand becoming elastic or very responsive to price change and price shifting from p1 to p2. This along with the introduction of new alternatives promoted by the German government to promote sustainability will result in a decrease in the quantity demanded (Q1 to Q2) of pesticides as high prices of pesticides will discourage use and yield a cheaper more sustainable alternative that progresses climate neutrality.

Analysis

The primary pesticides that dominate in terms of usage in Germany are Herbicides and Fungicides/Bactericides. Germany being one of the highest countries in terms of use also uses other pesticides like Insecticides/Acaricides and Molluscicides. With pesticide usage being so prominent it results in there being a heavy reliance on them and making them extremely important, especially when considering trying to maximize output as pesticides have an average of 30 percent yield increase and improvements in quality (Science direct).

Looking at the sales of pesticides in Germany between 2018-2020 from European union statistics there is a clear stagnation in the growth in sales. With this stagnation when comparing sales to the developing legislation from the German government little impact can be seen. Despite there being a strive to purposefully become climate neutral with an interest in lowering externalities from pesticides their usage sales remained the same. With safer and environmentally friendly practices it targets some of the main problems that arise when using pesticides. Hence why looking at sales and seeing percentage change with the progression of greener activities.

In the analysis, the Harmonized risk indicator will be included. The indicator shows trends for pesticides like measuring the use and risk of pesticides as well as the number of emergency authorizations that strengthen protection for a nation's public health. The indicator serves as a sign of progression in terms of the factors that make it up. The assumption is that a decreasing value indicates progression when it comes to better addressing the determinants of the indicator.

Table 1: Sales data of pesticides between 2017-2020

	Pesticide sales	Fungicides, bactericides, and Herbicides sales	Harmonized risk indicator
2017	48,307,108	30,018,541	91
2018	44,960,858	26,252,001	82
2019	45,181,227	24,163,329	83
2020	47,973,969	24,094,090	No data

(sales data from ec.europa.eu)

To calculate for percentage change for the prior year I used this percentage change formula:

$$Percentage\ change\ in\ sales = \frac{Current\ year - Previous\ year}{Previous\ year} \times 100$$

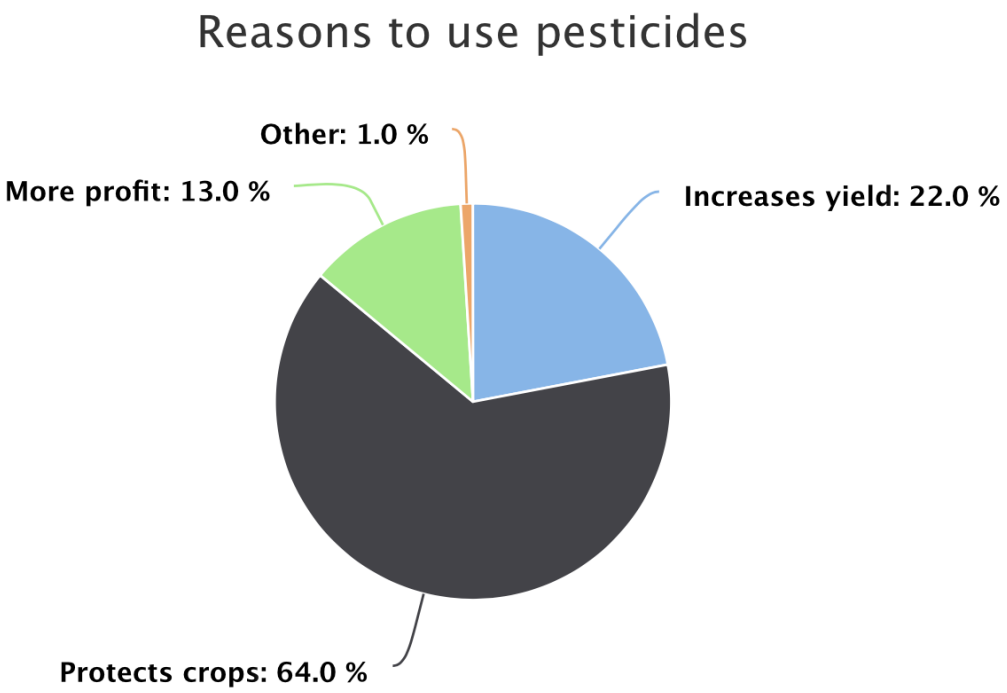
From the time 2017 of 2020 there was only a 0.69 change or decrease in the final sales of pesticides. The lack of any change at all can derive from the heavy reliance Germany has on pesticides. From the time frame analyzed there is however contrary to overall sales, a noticeable decline in the sales of Fungicides, bactericides, and herbicides. This decline can be attributed to Germany targeting the two most abundantly used pesticides which show some progression but in the whole perspective of declining sales, it had little effect. A decline in the use of these pesticides does still however show growth as it means other alternatives whether they are more natural or safer are being sought out to replace the current and more harmful types of pesticides.

In addition to the decline of the major pesticides the Harmonized risk also saw a decline from the year 2017 to 2018 where it then basically remained the same from 2018 to 2019. This also shows some progression as it entails that overall, maybe not in sales but in usage and protection there is an effect on these trends which resulted in the indicator lowering.

Determinants for using pesticides

Since farmers are the ones using pesticides, they would have very important reasons to still use pesticides despite the many problems that arise from them. These reasons would have to be acknowledged in order to effectively reduce usage without also harming farmers' revenue hurt too badly. The most frequent reasons are shown below:

Figure 5: Factors affecting the reason to use pesticides



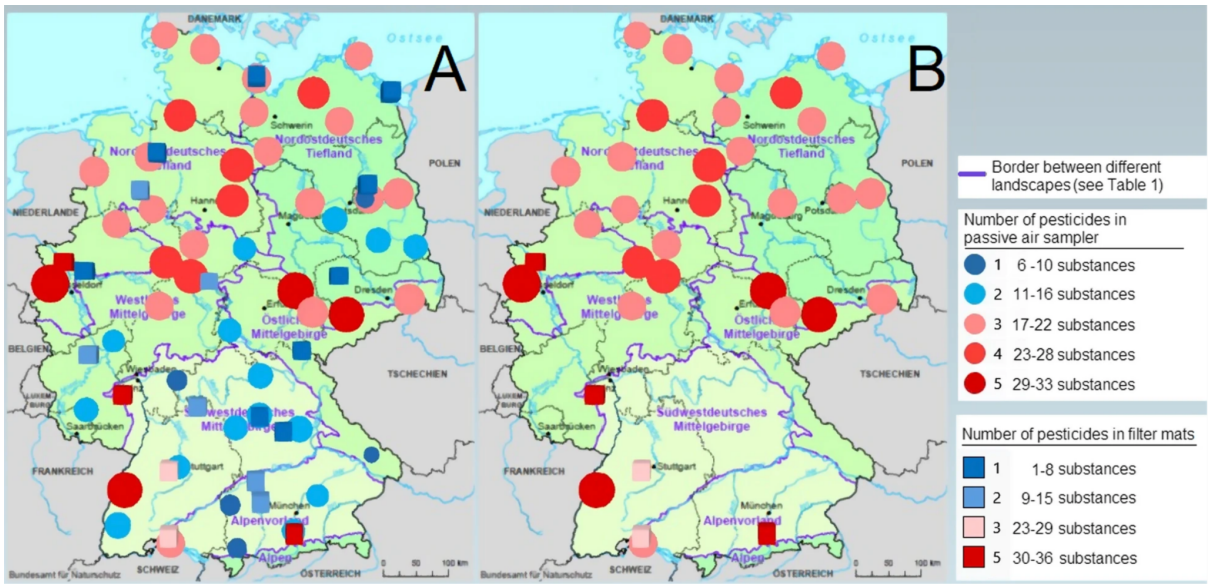
(Appendix 1, from candidate)

From the data, a majority of farmers use pesticides in order to protect crops which would signify that in order to promote using fewer pesticides there would have to be a substitute that could equally accomplish the same effects as pesticides. In addition to protecting crops from pests to lower crop loss, there was also mention of how the pesticides helped the product look better which is somewhat implied when protecting crops. From the farmers that said their reasons were for increased yield and more profit (35 percent in total) I would group together for their similarities but to show individual reasons were left separate. Looking at them separately for more profit, concern was expressed as some did not want to have to find alternatives because it could potentially affect and diminish profits. With the increased yield, not being able to produce at higher levels of output puts

farmers at a disadvantage when being competitive which also affects profits but also discourages using fewer pesticides or other alternatives.

When there are crucial factors when regarding diminishing pesticide usage and finding alternatives, it can be difficult which can explain the stagnation in progression. This connects to the sales as until a proven, effective and accessible alternative is created or found it is just incredibly hard to progress while still properly satisfying reasons to get rid of pesticides.

Figure 6: Prominence in air samplers



(Springerlink, 2021. appendix 2)

From the investigation carried out it was recorded that a high amount of pesticide substances was detected in northern regions of Germany. Uncoincidentally in the upper regions of Germany are where many agricultural fields are. From this majority of passive air, samplers appear red, indicating that across Germany far too many pesticides are being observed. Additionally, a high concentration of pesticides was detected in unexpected regions like parks in the region of Harz.

A clear and heavy contrast is noticeable between the northern and southern regions of Germany. Comparing A and B, there are no samplers in B that are blue because B shows only the highest recorded numbers. Contrary to B, many of the southern regions of A are showing lower concentrations of substances further showing the heavy concentration in the Northern region due to the abundance of farming land up there.

The results show how overconsumption of pesticides has now negatively left high amounts of traceable pesticide substances in the surrounding areas. Especially in the northern area residents are interacting with pesticide substances in the air which can lead to health problems in the long term.

Too many substances are being used in the northern regions and the high amounts recorded contribute to why it can be explained that not enough has been done to lower usage in Germany.

Evaluation/Reflection

Reflecting, I realized that not only in Germany but honestly everywhere in the world that pesticide usage is more prominent than expected. For the sake of the investigation and focusing on Germany some questions were formed during the investigation. I was unsure how countries like Germany with heavy use of pesticides would be able to convert to being climate neutral as easily compared to other countries that would have less trouble converting because their usage and impact on the environment are lower making it easier to adopt new methods. This connects to why I wasn't surprised to see Germany with little progress because of how large they are in terms of pesticide usage compared to other European countries.

In possible future investigations hopefully, more data will be available to show more progress in the continuous effort to lower pesticide usage. I would also possibly focus more on the firm and its employees and look at maybe incomes. This is because my parents both have worked in the agriculture sector and have told me repeatedly that pesticides were a reason why they were able to provide for themselves and for me and that giving them a negative connotation completely is unjustified and unfair to workers who rely on the sales and distribution of pesticides for their income. I saw two sides during the investigation of heavy restrictions and turning society against usage. I also saw how the benefits cannot be ignored and should not be ignored. An argument developed on how benefits are often connected to the capitalistic side and more focused on the profits while the drawbacks are connected to human health and its effect on the environment. This connection made it hard to really say which way of dealing with pesticides was appropriate

Limitations to the research method

The first limitation would be that data for 2021 wasn't available and some for 2020 weren’t available either. While doing research a problem also came from data being from the early 2000s making it unusable when trying to see the effects recently. I also had trouble trying to just find data on Germany's percentages. When it came to the sampled farmers not all of them were nearly close to

each other in the scales of their production. Also, 100 farmers can represent the whole country's opinions. Also, there was a language barrier as some were not as fluent in English as others.

Finally, there were slight difficulties trying to represent the effects without just showing sales which may not be the most reliable as many sources stated how farmers buy in surplus sometimes for various reasons which made it difficult to not feel like my analysis was worthwhile. Also just seeing the insignificant change resulted in some second-guessing of how effective it was looking at sales. I realized that sales only showed how heavy the reliance was and that the harmonized risk indicator showed better representation of the diminishing usage. Better representation I think could have come from a more recent set of data showing the sales.

Conclusion

Looking at the question: "**To what extent is the German government's intervention in pesticides accomplishing sustainability as part of a green future**" I've concluded that Germany has only slightly reduced pesticide usage and that there hasn't been enough done to have a clear impact which is evident in the sales.

Saying not enough has been done isn't a negative connotation as Germany has reformed pesticide usage in pursuit of being climate neutral and protecting consumer health. Organic farming which doesn't require synthetic pesticides is being better promoted along with the development of the National Action Plan for Plant Protection. This plan will strive to limit the effects created by using pesticides. Germany has however been given a poor rating in the past for plant protection and Agriculture Minister Cem Özdemir has been criticized for not creating stronger incentives for reducing pesticide usage (Euractiv, 2022).

There is also no clear noticeable decline in volumes because of the heavy reliance and dependence. As mentioned, Germany is one of the top countries in Europe when it comes to using pesticides creating a huge market for pesticide use. This would explain why Germany is having a hard time enforcing and creating an effective way to reduce pesticide usage.

To add it takes time to adapt to solutions and implement new alternative solutions such as biologicals with similar performance. This time of adoption and implementation cannot immediately occur which would explain why little progress has been made so far. Until the heavy reliance areas shown in figure 6 are lowered it will be difficult to lower that usage and provide an alternative.

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Appendices

Appendix 1: Results from survey with local farmers

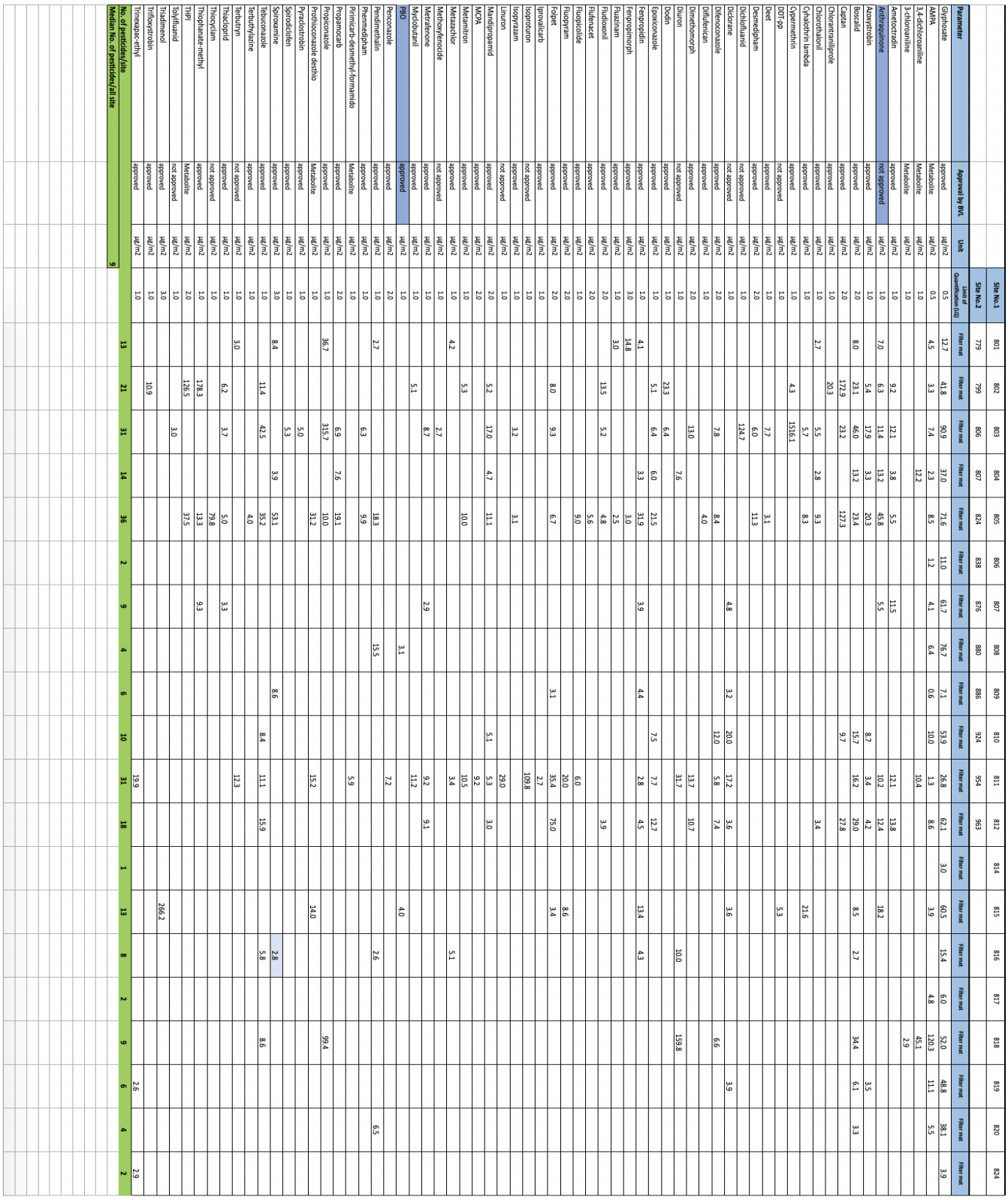
Warum verwendet ihr Pestizide?

- mehr Gewinn
- Ernten schützen
- erhöhter Ertrag
- Sonstiges

	Percentage of Interviewed
Mehr Gewinn (more profit)	**13 percent**
Ernten schützen (protect crops)	**64 percent**
erhöhter Ertrag (increased yield)	**22 percent**
Sonstiges (other)	**1 percent**

Appendix 2: Passive filter mats

(Source: Spring open, 2021)



Parameter	Approval by BVL	Unit	Site No.1	801	802	803	804	805	806	807	808	809	810	811	812	814	815	816	817	818	819	820	824
			Site No.2	779	799	806	807	824	838	876	880	886	924	954	963								
			Limit of Quantification (LoQ)	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat	Filter mat
Glyphosate	approved	µg/m2	0.5	12.7	41.8	90.9	37.0	71.6	11.0	61.7	76.7	7.1	53.9	26.8	62.1	3.0	60.5	15.4	6.0	52.0	48.8	38.1	3.9
AMPA	Metabolite	µg/m2	0.5	4.5	3.3	7.4	2.3	8.5	1.2	4.1	6.4	0.6	10.0	1.3	8.6		3.9		4.8	120.3	11.1	5.5	
3,4-dichloroaniline	Metabolite	µg/m2	1.0				12.2							10.4						45.1			
3-chloroaniline	Metabolite	µg/m2	1.0																	2.9			
Ametoctradin	approved	µg/m2	1.0		9.2	12.1	3.8	5.5		11.5				12.1	13.8								
Anthraquinone	not approved	µg/m2	1.0	7.0	6.3	11.4	13.2	45.8		5.5				10.2	12.4			18.2					
Azoxystrobin	approved	µg/m2	1.0		5.4	17.9	3.3	20.3					8.7	3.4	4.2						3.5		
Boscalid	approved	µg/m2	2.0	8.0	23.1	46.0	13.2	23.4					15.7	16.2	29.0			8.5	2.7	34.4	6.1	3.3	
Captan	approved	µg/m2	2.0		172.9	23.2		127.3					9.7		27.8								
Chloranthraniliprole	approved	µg/m2	1.0		20.3		5.5	9.3															
Chlorothalonil	approved	µg/m2	1.0	2.7		11.4	2.8	8.3							3.4								
Cyhalothrin lambda	approved	µg/m2	1.0		5.7	1516.1												21.6					
Cypermethrin	not approved	µg/m2	1.0		4.3																		
DDT pp	not approved	µg/m2	1.0															5.3					
Deet	approved	µg/m2	1.0			7.7		3.1															
Desmedipham	approved	µg/m2	2.0			6.0		11.3															
Dichlofluanid	not approved	µg/m2	1.0			124.7																	
Diclobrane	not approved	µg/m2	1.0																				3.9
Difenoconazole	approved	µg/m2	2.0			7.8				4.8		3.2	20.0	17.2	3.6			3.6					
Diflufenican	approved	µg/m2	1.0										12.0	5.8	7.4								
Dimethomorph	not approved	µg/m2	2.0			13.0		4.0						13.7	10.7						6.6		
Diuron	not approved	µg/m2	1.0				7.6							31.7				10.0		159.8			
Dodin	approved	µg/m2	1.0		23.3	6.4																	
Epoxiconazole	approved	µg/m2	1.0		5.1	6.4	6.0	21.5				7.5		7.7	12.7			13.4	4.3				
Fenpropidin	approved	µg/m2	3.0	4.1			3.3	31.9		3.9		4.4		2.8	4.5								
Fenpropimorph	approved	µg/m2	3.0	14.8				3.0															
Fluazinam	approved	µg/m2	1.0	3.0				2.5															
Fludioxonil	approved	µg/m2	2.0		13.5	5.2		4.8							3.9								
Flufenacet	approved	µg/m2	2.0					5.6															
Fluopicolide	approved	µg/m2	1.0					9.0						6.0									
Fluopyram	approved	µg/m2	2.0										20.0					8.6					
Folpet	approved	µg/m2	2.0		8.0	9.3		6.7				3.1	35.4	75.0				3.4					
Iprovalicarb	approved	µg/m2	1.0										2.7										
Isoproturon	not approved	µg/m2	1.0										109.8										
Isopyrazam	approved	µg/m2	1.0			3.2		3.1															
Linuron	not approved	µg/m2	1.0										29.0										
Mandipropamid	approved	µg/m2	2.0		5.2	17.0	4.7	11.1				5.1	5.3	3.0									
MCPA	approved	µg/m2	2.0										9.2										
Metamitron	approved	µg/m2	1.0		5.3			10.0					10.5										
Metazachlor	not approved	µg/m2	1.0	4.2									3.4					5.1					
Methoxyfenocide	approved	µg/m2	1.0		2.7																		
Metrafenone	approved	µg/m2	1.0		8.7					2.9			9.2	9.1									
Myclobutanil	approved	µg/m2	1.0	5.1									11.2										
PBO	approved	µg/m2	1.0							3.1							4.0						
Penconazole	approved	µg/m2	2.0										7.2										
Pendimethalin	approved	µg/m2	1.0	2.7				18.3										2.6				6.5	
Phenmedipham	approved	µg/m2	1.0					9.9		15.5													
Pirimicarb-desmethyl-formamido	Metabolite	µg/m2	1.0		6.3								5.9										
Propamocarb	approved	µg/m2	2.0			6.9	7.6	19.1															
Propiconazole	approved	µg/m2	1.0	36.7		315.7		10.0												99.4			
Prothioconazole desthio	Metabolite	µg/m2	1.0					31.2					15.2					14.0					
Pyraclostrobin	approved	µg/m2	1.0			5.0																	
Spirodiclofen	approved	µg/m2	1.0			5.3																	
Spiroxamine	approved	µg/m2	3.0		8.4		3.9	53.1				8.6						2.8					
Tebuconazole	approved	µg/m2	1.0		11.4	42.5		35.2					8.4	11.1	15.9			5.8		8.6			
Terbuthylazine	approved	µg/m2	1.0					4.0															
Terbutryn	not approved	µg/m2	1.0	3.0									12.3										
Thiacloprid	approved	µg/m2	1.0		6.2	3.7		5.0		3.3													
Thiacyclam	not approved	µg/m2	1.0					79.8															
Thiophanate-methyl	approved	µg/m2	1.0		178.3			13.3		9.3													
THPI	Metabolite	µg/m2	2.0		126.5			37.5															
Tolylfluanid	not approved	µg/m2	1.0			3.0																	
Triadimenol	approved	µg/m2	3.0															266.2					
Trifloxystrobin	approved	µg/m2	1.0																				
Trinexapac-ethyl	approved	µg/m2	1.0		10.9									19.9							2.6		
No. of pesticides/site		**9**		**13**	**21**	**31**	**14**	**36**	**2**	**9**	**4**	**6**	**10**	**31**	**18**	**1**	**13**	**8**	**2**	**9**	**6**	**4**	**2**
Median No. of pesticides/all site																							2.9