POTENTIAL IMPACT OF THE EUROPEAN GREEN AGREEMENT ON EU AND HUNGARIAN CROP PRODUCTION

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Abstract: *European arable farming, including Hungarian arable farming, faces a huge dilemma: how to contribute to and maintain the global food supply while reducing greenhouse gas emissions while main taining biodiversity, but reducing inputs that are potentially damaging to society and the environment while ensuring that no more land is taken out of production? Not to mention that the increasingly urgent need to tackle climate change is also placing additional demands on EU agricultural decision-makers. Under the European Green Deal (GD), the 'From Farm to Fork' (F2F) strategy will help achieve climate neutrality by 2050, with a target of a 55% reduction in greenhouse gas emissions by 2030. Achieving this will require significant changes in food production, a shift in crop health strategies and accelerated innovation in the agricultural sector. The study addresses these issues. Our first hypothesis (A1) is that the GD and F2F strategies can be implemented without problems and without losses. Our second assumption (A2) is that the know-how solutions and the technological conditions for precision agriculture that are already available exist, and that all of these already justify the feasibility of A1. In order to prove this, we have reviewed recent and up-to-date literature on DG and F2F. For A1, we found that there are pro and con findings in the literature. However, the summary finding is not positive. The conclusion of the studies, based on data calculations, is that EU agriculture faces huge additional costs if it is to maintain production and reduce environmental pressures. Their calculations suggest that more people will be disadvantaged by the decisions, and that millions of euros could be lost to the public. However, the article also shows that there are many cases where positive results can be achieved even with reduced chemical use. Facts and figures from international and Hungarian technological and know-how solutions and their trials at plant level show that the DG's objectives are already partially achievable. It has been established that the systematic use of precision technologies allows to increase the natural and at the same time the economic efficiency. In our work we have used the results of primary and recent secondary research. We have shown the downsides of GD, but also that with targeted support, the objectives of sustainability and GD can be approached. Changes in 2022, drastic price increases for inputs including fertilizers and pesticides, inflation at a 20-year high, energy prices spiraling out of control, and an almost unprecedented drought affecting crop production and horticulture, point to the need for a radical change in technology, thinking and regulation. And all this to ensure that there is enough affordable food in Hungary, that there are export products within and outside the Community, and that those working in agriculture have a decent living.*

(Jel Code: O13, Q15)

INTRODUCTION

Established in 1962, the Common Agricultural Policy (CAP) has absorbed more than 40 percent of EU expenditure. The original objectives of the CAP were to increase productivity, provide a fair standard of living for the farming community, stabilize markets and ensure sufficient food for European consumers. Since its introduction, the CAP has undergone a number of changes, with the main objectives being given a new emphasis, including food safety, animal health and welfare, and then environment and nature protection. The main policy objectives of the new CAP for the second decade of the 21st century are: to ensure a fair income for farmers; to improve competitiveness; to improve the position of farmers in the value chain; to take action on climate change; to protect the environment; to preserve landscapes and biodiversity; to support generational renewal; to stimulate the rural economy; to protect food quality and health; to improve knowledge and innovation. In parallel with these objectives, a new political reflection on sustainable development has been launched among EU policy makers. This has resulted in new policies and action plans. These include the European Green Deal (GD), the Next Generation EU, the EU Biodiversity Strategy, the European Forestry Strategy and finally, in May 2020, the Farm to Fork (F2F) strategy for agriculture.

The European Green Deal was presented by the European Commission in December 2019, declaring that Europe will become a climate neutral continent by 2050. Following the publication of the Communication (11 December 2019), legislation has been launched in a number of areas, with legislative changes expected in climate targets, energy, transport, environment, agriculture and industrial policy (COM, 2019). It is perhaps interesting to note that seven years ago it was said that "greening" per se does not attract much attention among agri-food business leaders unless it is coupled with an end to economic waste". At least, this was the view in 2015 (Zokaei et al., 2015). The European Commission presented its proposal for the adoption of a climate agenda in March 2020, followed by the adoption by European leaders in December 2020 of a new target for the EU to reduce net EU carbon emissions by at least 55% by 2030. The European Parliament and Member States reached a political agreement on the European

Climate Action Plan in April 2021, and the regulation entered into force in June 2021. It also included strategic targets for biodiversity. The areas that affect agriculture are:

1. at least 30% of EU land is designated as protected areas;
2. limit urban sprawl;
3. reduce the risk of pesticides;
4. restore at least 10% of agricultural land with high landscape diversity;
5. 25% of the EU's agricultural land should be farmed organically;
6. make progress in restoring contaminated land;
7. reduce soil degradation and
8. plant more than three billion new trees (Montanarella and Panagos, 2021).

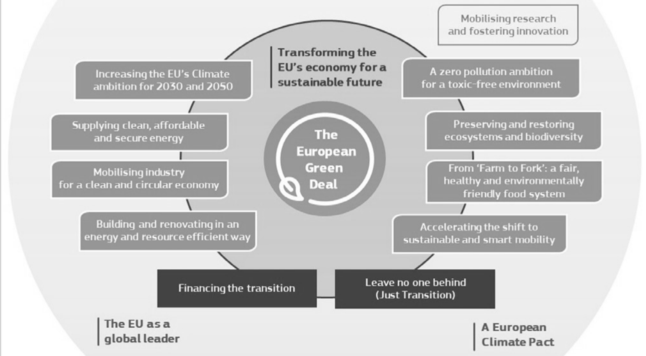
Following the climate change agenda, the European Commission presented the "Soil to Table" F2F strategy in May 2020, one of the key actions of the European Green Deal. Aimed at achieving climate neutrality by 2050, the strategy declares that

1. reduce pesticide use by 50%,
2. reduce fertiliser use by 20% by 2030.
3. it also foresees a 50% cut in antibiotics,
4. and would increase the proportion of land under organic farming from 8 to at least 25% (Basics of a rethink of the farm to fork strategy, 2021).

As several authors have argued, F2F can be linked to the UN Sustainable Development Goals (SDGs) by having as one of its main objectives the reduction of negative environmental, social and economic externalities associated with the production of food and drink (Capozzi et al., 2021). On 19 October 2021, the European Parliament voted in favour of the report on the Farm to Fork Strategy presented by the European Commission, giving the green light to start the legislative work needed to achieve the objectives of the strategy.

The European Green Deal addresses several priority areas, of which four broad groups are easily identifiable and Figure 1, which promotes the implementation of the deal, provides a very comprehensive picture of these areas.

Figure 1: Areas of the European Green Deal



Source: COM, 2019

One of these areas is clean energy, which means that if the targets are met, energy consumption will fall by 36% and the share of renewable energy will rise to 40%. The EU energy embargoes on Russia, extended in June 2022, are likely to hamper the timely achievement of the target. The renewal of buildings, including the energy modernisation of public buildings, will also contribute to increasing the use of renewable energy. Sustainable transport aims to significantly reduce carbon emissions, so only new cars with zero emissions are expected to be on the road by 2035. The fourth call to action is to work with nature, which foresees the planting of three billion new trees and includes the sustainable use of biomass. In the light of the GD and F2F regulations, we believe that the Green Deal will have the greatest impact on agriculture in terms of arable crops and their yields and production efficiency. The F2F strategy's objectives to be met by 2030 include a strong set of standards for environmental sustainability. All of these have a direct or indirect impact on arable crops. In our study, we want to analyse whether it is possible to prioritise environmental sustainability, which is otherwise very sympathetic, and whether this is compatible with social and economic sustainability. We will explore the literature, the tools, technologies and empirical experiences that are potentially available to achieve environmental feasibility.

Research assumptions on the topic:

A1: Our first assumption is that the GD and F2F strategy is feasible without problems and without losses.
A2: Our second assumption is that the know-how solutions and the technological conditions for precision agriculture that are already available are given, and that all of these already demonstrate the relevance of the GD's requirements.

METHODOLOGICAL ISSUES OF LITERATURE PROCESSING AND RESEARCH

Secondary research methodology

The following methodology was used to process the international literature on the topic: first, the topic and keywords were searched for "Green Deal" in Clarivate Web of Science, one of the largest databases available online. The result was 8079 hits. These publications were published between 1982 and 2022, and in terms of number, mainly in the last 5-7 years. For this reason we changed the starting year from 1982 to 2015. As a result, the number of articles has been reduced to 5240.

We then took two steps to narrow down the number of publications: on the one hand, we further reduced the time interval and, on the other hand, we restricted the subcategories of Web of Science.

The narrowing of the time interval was linked to the publication of the Green Deal, i.e. we searched for publications from 2019 onwards. The main focus of our work was not the scientific preparation for the development of the GD, but its potential impact on EU and Hungarian crop production. In 2019, 692, in

2020 928, and in 2021 1256 publications were about the Green Agreement. In 2022, the number of publications increased further with 464 papers.

In terms of subcategories of publications, 978 papers were on environmental science, 446 on green sustainability and 118 on economics.

In order to identify the rather large number of publications and their disciplinary "clusters", we have again carried out a narrowing down. Here we have used the Rayyan interactive software for literature processing. The software is designed to provide the analyst with keywords and summaries of articles and to exclude possible duplications. Following the timing of the EC and EP decisions, we have specified the co-occurrence of the terms Farm to Fork and Green Deal keywords between 2019 and 2022. The result was only 37 hits in June 2022. The 37 publications were then processed. Where the keywords and abstract of a publication were found to be relevant to the title of the study, they were collected separately and downloaded in full to the computer if deemed necessary. Following the downloads, a detailed literature review of our article was carried out.

Primary research database

KITE Zrt. has offered technologies and proposals for greening in line with GD and F2F expectations well in advance of policy decisions. Practice preceded political decisions, the development of theories and the laying of the necessary theoretical foundations were and are still being done with a practice-oriented approach, today the possibilities offered by IoT, cloud-based information flows, data mining, mobile internet have at least quintupled the possibility of information flows and availability in 10 years.

Intelligent sensors in agricultural machinery capture a wealth of data that can be used as the basis for complex spatial and temporal, technical and agrotechnological analyses. This data is generated in John Deere's proprietary system, stored in the on-board computer (monitor) of the power machine or synchronised directly via remote data transfer to the MyJohnDeere portal, where the consultant and/or farmer can evaluate/analyse the information required. Following the collection of the so-called documented operational data, KITE Zrt. carried out a comprehensive study between 2012 and 2013 based on its own measurements to measure, analyse and quantify the development of inputs and incomes of different cultivation technologies (conventional, precision, band). The studies have included a more penetrating study of fuel use, labour input, nutrient replenishment, differential number of plants and input requirements for crop protection.

The study used technological data from a farm of more than 2000 ha. These data are based on exact measurements, as the modern power and working machines of the test farm have a sensor capability that continuously documented certain machine diagnostic and agronomic (input material yield and harvesting) parameters. The recorded data were extracted from the on-board computer of the tractor/combine and subjected to technological and tabular analyses. Much of the extracted data can be interpreted as spatial information, as modern technology allows the GPS system to document coordinates. The traditional precision and banding technology mentioned earlier was also carried out using GPS to capture the data. The spatial and temporal information also allows for a breakdown below the table level, although no such (crop) site-specific analyses have been carried out. The labour time input and specific fuel consumption were calculated as a function of the number of runs of the technology, based on technical discussions with the agronomic manager of the company concerned.

The data were compared with the AKI (Institute of Agricultural Economics) Test Farm Information System, which monitors the wealth, financial and income situation of Hungarian commodity-producing agricultural enterprises on a yearly basis through a representative sample of 2100 farmers. The system is mandatory for EU Member States, but farms are required to provide data on a voluntary basis. In addition to farm-level accounting and production data, sector-level cost and income data are an important part of the system in Hungary (Keszthelyi and Molnár, 2015).

Specialised geospatial software (SMS Advance and ArcGIS) was used for the data sorting (data cleaning, data filtering, spatial interpolation, tabular data aggregation) from the test farm of KITE Zrt. and Microsoft Office™ and SPSS for the basic statistical analyses.

LITERATURE PROCESSING

Recent publications show that there is agreement among green policy-makers on the GD and F2F provisions, but also negative opinions. In their study, Baquedano et al. (2022) predict that policies restricting the use of agricultural inputs have been shown to reduce production, farmers' incomes and increase food prices, which may ultimately lead to increased food insecurity. Estimates have been made for the EU and the world. Their results show that, compared to the current situation, input constraints will lead to a net increase in food insecurity, affecting 30 million people (EU only) and 171 million people (global) by 2030.

The European Commission's Farm to Fork (F2F) strategy under the European Green Deal recognises that innovative techniques, including biotechnology, can play a role in increasing sustainability. At the same time, organic farming will also be promoted, and at least 25% of EU farmland should be farmed organically by 2030. How can biotechnology and organic farming be both developed and promoted to contribute to achieving the Sustainable Development Goals? The increase in organic production envisaged in the F2F strategy could lead to a less sustainable food system policy, not a more sustainable one. The authors of this research (Purnhagen et al., 2021) have raised questions that are clearly aimed at EU policy makers, but also perhaps at the sustainable development community. These were:

1. How can a regulatory framework be developed that allows the combined benefits of organic farming and biotechnological innovations to be harnessed?
2. How can effective communication be developed to demonstrate that many biotechnology breeding innovations do not violate the organic principle of cell integrity?

3. How can effective policies be developed to address the conflicting objectives of the EU Commission's F2F strategy?
4. Which features of organic farming contribute to and/or threaten the achievement of the SDGs?

Which characteristics of biotechnological innovations can help address the weaknesses of organic farming in achieving the SDGs? (Purnhagen et al., 2021)

A further analysis of the related literature reveals that sustainability is increasingly becoming a priority in EU policies, especially in the Common Agricultural Policy. These include those focusing on the Sustainable Development Goals (SDGs), the European Green Deal and the F2F strategy, and those that attempt to establish links between all these and the EU's trade policy (Pietrzyck et al., 2021).

The European Green Deal, F2F and biodiversity strategy set the scene for the future review of the Common Agricultural Policy (CAP). The CAP will address an increasing number of objectives, including the contribution to the Sustainable Development Goals and the Paris Climate Change Agreement. To enable evidence-based policy making and monitoring, the Farm to Fork strategy proposes to extend the current monitoring system to a wider range of sustainability issues. The monitoring system of the Farm Accountancy Data Network (FADN) places a strong emphasis on financial and economic data. The FADN is a tool for monitoring and evaluating the EU's Common Agricultural Policy and collects accounting results from 80 000 farms. The expansion into a Farm Sustainability Data Network (FSDN) should include a wider range of indicators on farm sustainability performance. This document estimates the costs of this wider collection of sustainability indicators in the FSDN, based on the experience of the pilot project in 9 Member States and a survey of all Member States. The results show that collecting sustainability data from all farms in the FADN would increase costs by around 40%. The results show large variations between countries depending on the current costs of data collection and the expected additional work involved in including sustainability indicators. Given the high demand for this data, a scenario has been developed in which sustainability data is collected from a sub-sample of 15 000 farms. This could be achieved within the current budgetary constraints by reducing the INHH sample from 85 000 to 75 000 farms. The discussion section addresses some of the concerns raised about the extension of the FADN to FSDN, such as the willingness of farmers to use the FADN, the administrative burden on farmers, the need to maintain the FADN and the need to ensure that the FADN is not overly burdensome.

How do we measure progress? EGD theory has also inspired researchers to develop new analyses and indices. For example, (Dabkiene et al., 2021) proposes the introduction of the Agri-environmental Footprint Index (AFI) as an indicator to determine the current state of the environment and to monitor changes and outcomes on farms. The subject and its scope are so broad that it includes the circular economy, a subset of the bio-economy. Some authors argue that in order to recover nutrients from nutrient-rich wastes, attention should be directed towards treatment processes that lead to the production of mineral fertilizers that can be further utilized. The Commission strongly recommends this as part of the F2F strategy, which is an integral part of the EGD. An interesting approach is taken by Lalander and Vinneras (2022), where they describe how insects are nature's waste managers and can play a vital role in closing the loop of nutrients returned from society to the food industry, thereby reducing the environmental impact of our food production system, as is the aim of the EU's F2F strategy. Insects can be used to convert biodegradable waste into biomass that can be used as food or animal feed, thus linking waste management to food production. However, food safety regulations prevent around 70% of the food waste available in the EU from being used as a substrate for insect breeding. In order to reap the true environmental benefits of insects as an alternative source of protein, a legal and hygienic framework must be found to allow insects to be reared on mixed food waste in the EU.

Another new area is the issue of pesticides. More people are feeling the challenge of what is implied by GD and F2F. Biodiversity by 2030 is a strategic challenge for the evaluation and authorisation of pesticides, where risk management will be a key element for the approval of active substances and the authorisation of pesticides (Molteni and Alonso-Prados, 2020).

IT is the next key issue for the implementation and enforcement of GD and F2F. There is a saying that "the greatest inhibitor of any change is the human element itself". Almost all elements of the EU's GD require basic digital skills. People with IT skills look at digital technologies as an opportunity for a sustainable future. People working in agriculture and living in rural areas who do not have such skills do not recognise the digital transformation process and treat it as an enemy (Rijswijk et al., 2021). It is likely that in this area, too, there is a need for training and broad information to increase the capacity to adopt and accept digital skills.

The Covid pandemic affected the world in a way and to a degree that few could have predicted, causing severe disruption in many industries. Despite this, crops were sown and harvested, food was produced and agriculture continued to function, albeit with many logistical challenges. European arable farming faces a dilemma: how to contribute to and sustain global food supply while reducing greenhouse gas emissions, not reducing biodiversity, but reducing inputs that are potentially damaging to society and the environment, while ensuring that no more land is taken out of production? In Europe today, it is not only the Covid epidemic but also the increasingly urgent need to tackle climate change that is driving change! Under the European Green Deal, the F2F strategy promotes climate neutrality by 2050 and aims to reduce greenhouse gas emissions by 55% by 2030. Achieving this will require significant changes in the way food is produced, a shift in plant health strategies and accelerated innovation in the agricultural sector. Such results have been reported by researchers in the areas of crop protection and nutrient replenishment.

Bryson (2022) discusses how the use of synthetic fungicides contributes to plant health and the management of greenhouse gas emissions. It also explores future challenges and prospects for their positive contribution to achieving global food security, while using new innovative technologies.

In particular, the F2F strategy aims to reduce the use of pesticides and mineral fertilisers, but also supports the development of organic farming. At the same time, food demand is increasing. These ambitious challenges require extensive research, development and innovation. Therefore, new non-chemical techniques to improve plant growth and resilience to biotic and abiotic stresses need to be explored for their potential in this area. One of the most promising is the use of non-thermal plasmas for such purposes. As this physical agent is a complex mixture of ions, atoms, electrons, radicals and molecules, its effects on plants and pathogens are complex. Pańka et al. (2022) reviewed the literature and found evidence for the potential use of non-thermal plasma for plant growth enhancement and crop protection.

Wesseler (2022) concludes that F2F strategy as part of the GD reduces agricultural production in the EU and causes food prices to rise. This is expected to further increase consumer price inflation in the EU and beyond. However, farmers' incomes in the EU are not expected to fall in the near future. The F2F strategy could result in a redistribution of subsidies from consumers to farmers in the EU. On average, studies evaluating the economic impact of the F2F strategy show a reduction in welfare (economic) and, strange as it may seem, well-being (economic and social) in the EU due to the implementation of the F2F objectives. However, the studies do not fully quantify the environmental and health benefits of the F2F strategy, but they do include well-being. It remains doubtful whether the environmental and human health impacts will be sufficient to offset the expected welfare losses. Similarly, Wesseler (2022) is of the opinion that there are also doubts about the logical consistency of the F2F objectives and targets, and their relationship with the objectives of the GD and the nCAP. A reduction in agricultural production in the EU could lead to spill-over effects in regions outside the EU, which could undermine the objectives of the GD.

Achieving the objectives of the F2F strategy (limiting the use of herbicides) is expected to increase the work and expenditure on soil cultivation. Tillage is associated with an increase in greenhouse gas emissions. The impact of the F2F strategy on reducing greenhouse gas emissions, which is the main objective of the strategy, remains highly debatable. Although studies evaluating F2F have reported positive effects on greenhouse gas emissions, changes in land use practices have not been explored. The positive impact of the F2F strategy on food security is also questionable. Studies that have looked at crop emissions have predicted a decline in EU production and an increase in food prices. Cereals, but also other 'over-populated' crops, are at higher risk of production because of their lower disease resistance due to their very high 'potential yield'. The reduction in pesticide use limits the ability of crops to respond to biotic and abiotic stresses and to withstand extremes. This is expected to reduce food security for low-income households within the EU and reduce the EU's contribution to food security abroad (Montanarella and Panagos, 2021).

The impact of the F2F strategy on biodiversity is difficult to assess. Different forms of agricultural production and product production have different impacts on biodiversity. Whether the impact will be positive or negative depends on how biodiversity is measured. The use of measures that take into account the number of species and a certain frequency of species may not result in higher levels of biodiversity in line with the objectives of the F2F strategy. A more detailed assessment would require a ranking of species values, which raises the question of how the ranking is implemented and how civil society is involved. One study used a biodiversity indicator and reported positive impacts on biodiversity at the farm level (Beckman et al., 2020).

The assumptions and implications discussed above are based on the assumption that no further drastic institutional-strategic changes are expected after the introduction of GD and F2F, and that technological developments and innovations will be subordinate to them. According to Wesseler (2022), in the longer term, the F2F strategy is expected to lead to a reallocation of input factors, increasing the efficiency of production and distribution in EU agriculture. However, these changes will take time and it is clear that the policy level can influence the length of time over which these changes take place. A reallocation of factors could be facilitated by a reduction in restrictions on land swaps or foreign direct investment inside and outside the EU. Technological change can be supported by reducing the time needed to approve alternatives to chemical pesticides and providing stronger incentives to use modern biotechnology to address the many challenges facing crop production. It is in the hands of EU policy makers to transform the F2F strategy into a prosperity-enhancing strategy by implementing the necessary institutional changes.

The EU's F2F strategy, launched in 2020, also aims at a comprehensive sustainability transition of the European agri-food sector. However, as the strategy itself acknowledges and various impact evaluations (Barreiro-Hurle et al., 2021; Beckman et al., 2020; Henning et al., 2021; Noleppa and Cartsburg, 2021) have shown, political will alone will not achieve ambitious targets. Success depends to a large extent on innovation, both scaling existing innovations and developing entirely new ones (Reinhardt, 2022). To support these, consider first the results presented by Beckman et al. (2020) (Table 1).

Table 1: Estimated impacts in the EU and the world following the F2F and Biodiversity Strategies under different scenarios up to 2030

Scenario		Producers incomes changes in, %	Consumer Expenditure change, USD/ person/ year	GDP change in, billion USD	Food-Change in the number of people living in insecurity, million persons
EU adaptation	EU	–16	153	–71	–
	Word	+2	51	–94	22
EU+ EFTA-adaptation	EU	–8	651	–186	–
	Word	+4	159	–381	103

Source: Beckman et al. (2020)

The estimated effects in the EU are clearly projected to be a fall in producer incomes in the range of 8-16 percentage points, an increase in consumer spending in the range of USD 153-651 per capita per year, and a fall in GDP of USD 71-186 billion. To make matters worse, the number of people living in food insecurity worldwide could increase by 22-103 million.

However, it should be noted that the economic evaluation of agricultural policies is not a trivial task. Any economic evaluation model is a simplification of reality; it may therefore contain uncertain assumptions. Nevertheless, models can help by providing information on the possible consequences of policy choices. In the EU, new legislation and policies require impact assessment, including forward-looking studies under the Better Regulation programme, to ensure, in the Commission's words, evidence-based and transparent EU legislation based on the views of stakeholders. However, not only one but several applied models have been developed for evaluating EU agricultural policies. However, they differ in terms of the time and space dimensions they cover, the detail of the sectors they cover, and their environmental and other impacts. This was reviewed in the study by Varacca et al. (2020). As reported by Wesseler (2022) in the European Commission's Joint Research Centre, models for assessing the impact of EU agricultural policies are maintained and continuously updated. One of the widely used models is the Common Agricultural Policy Regional Impact Assessment (CAPRI) model, which is used for ex ante impact assessment of agricultural and international trade policies. Barreiro-Hurle et al. (2021) and Henning et al. (2021) used the CAPRI model to assess the impacts of the F2F strategy. Noleppa and Cartsburg (2021) used the multi-market model described by Lüttringhaus and Cartsburg (2020) and Beckman et al. (2020), the GTAP-AEZ (Global Trade Analysis Project - Agro Ecological Zone) multi-regional, multi-sector, computable general equilibrium model to assess the impact of the F2F strategy. The evaluation of the F2F strategy by Bremmer et al. (2021) combined case studies for ten crops from seven countries (Finland, France, Germany, Italy, Poland, Romania and Spain) with the AGMEMOD (Agricultural Member State Modeling) partial equilibrium model.

Table 2: Results of studies on the impact of the F2F strategy on agricultural production, % in the EU

Cereals	Oilseeds	Vegetables, fruits, plantations	Fodder crops	Beef and veal	Dairy products	Sources
−15,0	−15,0	−12,0		−13,0	−10,0[d]	Barreiro-Hurle et al., 2021
−48,5[a]	−60,7	−5,2[c]		−13,5	−11,6	Beckman et al., 2021
−18,0[a]						Bremmer et al., 2021
−23,6	−7,3	−13,0	−30,0	−17,0	−6,0	Henning et al., 2021
−26,0[a]	−24,0[b]					Noleppa et al., 2021

[a]Only wheat, [b]Only rape, [c]Only vegetables and fruits, [d]Pour milk
Source: Wesseler (2022)

One of the challenges of modelling the F2F strategy is to combine different objectives, as the effects overlap. For example, increasing organic farming already includes reducing the use of chemical pesticides and mineral fertilisers.

Farm to Table and Biodiversity strategies, as we have seen, have been subject to a number of impact assessments. In his work, Wesseler (2022) has processed the findings of F2F strategies reported by different groups of authors. Two summary tables from his work are presented here (Tables 2 and 3).

Table 3: Results of the study on the aggregate economic impact of the F2F strategy

Farm income	Food expenditure	GDP	EU production value, billion EUR	Authors
Growing	Growing	Decreasing		Barreiro-Hurle et al., 2021
–16%	153,2 USD/fő	–84,2 milliárd USD[d]		Beckman et al., 2021
Decreasing			–140	Bremmer et al., 2021
+35,08 billion EUR	70 billion EUR[b]	Decreasing	Growing	Henning et al., 2021
>15 billion[a]	Growing[c]	Decreasing[c]	Decreasing	Noleppa et al., 2021

[a]Only crop production was considered and calculated for 2040, [b]Expressed as total consumer surplus, [c]Indirect inference from the decline in production and the general model description, [d]Only in EU case
Source: Wesseler (2022)

The studies consider different scenarios, which examine the impacts of the Farm to Table (F2F) and Biodiversity strategies on EU agricultural production, production prices and external trade in the food economy, in addition to welfare impacts. They also quantify the expected environmental impacts and mention the spill-over effect. Detailed methodological and implementation exercises can be found in the original study.

The studies conclude, as already mentioned, that the new regulation is expected to have negative impacts on EU agricultural production, production prices, external trade of the EU food economy and welfare effects, but that the expected environmental impacts are positive even if the spill-over effect is taken into account.

In the light of the above, we do not consider our first assumption (A1) that "the DG and F2F strategy can be implemented without problems and without losses" to be justified. The results of five modelling exercises all indicate that the new regulation has negative impacts in most measurable cases (production, output prices, foreign trade, welfare). However, the studies do not quantify the environmental and health benefits of the F2F strategy. It is doubtful whether the effects on the environment and human health will be sufficient to offset the expected welfare losses. However, we have also seen that there are a number of promising novel existing research results that can be put in the bag of GD proponents. It should also be noted that all the studies essentially start from an analysis of past time series and calculate absolute yield reductions for expected impacts for different agricultural sectors. This can also be explained by the fact that it does not take into account the effects of technological responses to changes in rules, improvements on yields, input use and production efficiency.

THE RESULTS OF PRIMARY RESEARCH

Machinery, machinery connections, installed equipment, modern genetic background, IT developments and with them digital solutions are taking off in agricultural production. The adaptive technologies used have evolved significantly over the past decades, leading to improvements in efficiency on both the yield and input sides. All these factors together mitigate the expected negative effects of the F2F strategy, and in themselves represent partial compliance with the European Green Deal.

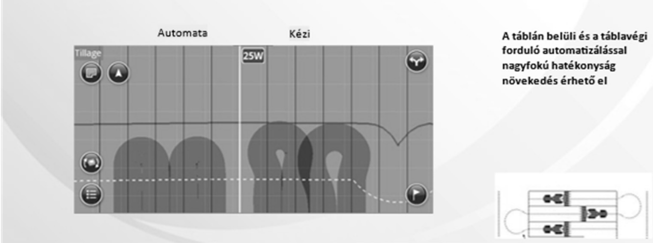
Arable crop production deserves special attention, since the improvement in natural efficiency is not only measurable, but can also be documented thanks to modern information technology solutions.

Today, agriculture is one of the leading sectors in terms of the practical application of the latest IT developments, mainly due to the use and application of circuits, displays, information technology tools, AMS devices, sensors, chips, automatic electro-pneumatic and hydraulic systems built into agricultural machinery and the use of geo-information systems, including positioning systems.

The first milestone in the technological development of conventional field crops and cultivated over large areas was the emergence of positioning systems and their subsequent use in agriculture.

These systems make it possible to carry out the operations required for successful cultivation technology more quickly, over a large area, in a repeatable manner (in space and time), without overlapping and without skipping, and accurately and efficiently, even over large working distances, provided that the opportunities and capabilities offered by the improvements made by the machine manufacturers (e.g. automatic steering) are used professionally by the personnel operating the machines. Automated steering and the automation of certain technological operations alone can be expected to result in fuel savings of at least 5-8%, which will go hand in hand with a reduction in emissions and an increase in operational efficiency.

Figure 2: Positive benefits of automatic steering



Source: KITE Zrt.

The advent and use of section control allows the separation of yes/no operations. Section control allows that, when certain technological operations are carried out, the machine carrying out the technological operation can not only apply the input material over the full working width by using the positioning systems built into the machine and direct communication between the machine and the implement, but can also pause the application of the input material in the area already treated or not requiring treatment, based on signals sent by the machine. A glaring example is when some of the nozzles on the spray wheel of a power-trailed sprayer, controlled by an on-board computer, are deactivated as it passes over the crop once treated, resulting in further operational efficiency improvements and input savings of between 2-7%.

The next step in precision technology is to combine certain technological operations to achieve a reduction in the number of passes, a good practical example of which is the combination of seedbed preparation, band spraying, soil disinfectant application, seeding and starter fertilisation in one pass. The combined technology described above can be carried out with a combination of power-driven machines and seed drills, which, in addition to saving fuel and inputs, meets the requirements of soil conservation technology (less disturbance, dusting, soil treading) and allows better use of inputs.

The use of machine couplings for differentiated and positioned input material delivery will bring further natural efficiency gains. Instead of averaging, the savings on the input side can be as high as 50% if the inputs are applied differentially within the field, at doses and positions adapted to the site conditions, to the specific needs of the crop, optimised to achieve the intended yield target.

Both in the area of crop protection and in the area of nutrient supply, there are examples (positioned band weeding, positioned mechanical weeding with differential and positioned N application, differential nutrient supply based on management zones) where some interventions offer additional benefits on top of the real savings. A typical example in maize is liquid N applied in combination with intercropping and positioned in the root zone of the crop, when an inhibitor is used, as the input savings are associated with a reduction of losses and an improvement in input utilisation.

The principle of differentiation must be applied to all technological interventions (variable depth tillage, nutrient replenishment, seeding, crop protection) in order to achieve a synergistic effect, so that the application of systems thinking in practice leads to the greatest possible natural (and therefore, unchanged yields) and economic efficiency gains.

The above statements are supported by quantifiable data and comparisons based on KITE Zrt.'s own test results, which can also be measured in terms of natural efficiency, and which will be presented using the example of fodder maize cultivation technology.

Between 2012 and 2013, KITE Zrt. measured and quantified the specific fuel consumption of different maize cultivation technologies (strip-tillage, loosening and ploughing) in its own studies. Analyses were carried out at 11 sites on 198 plots with different soil types (sandy loam, loam, loamy loam and clay) and different pre-crop types (maize, soybean, winter wheat, sunflower, rape and mustard used as green manure). The study was carried out in sunflower and maize crops.

However, when fuel consumption data were analysed, significant differences were found, not only due to technology but also to soil texture (Table 4).

Table 4: Fuel consumption for a given cultivation mode, l×ha^{-1}

Soil texture	Fuel consumption for a given cultivation mode		
	Strip-tillage	Decompaction	Ploughing
Sandy loam	10,2–11,3	12,7–14,2	21,9–23,6
Trough	11,8–12,9	14,6–16,7	24,8–27,8
Clay- loam	13,2–14,6	17,2–19,8	28,2–31,8
Clay	14,7–16,9	20,2–23,5	32,1–35,7

Source: KITE Zrt.

When comparing the different technologies, the specific fuel consumption (expressed in litres per hectare and per hectare) resulted in a 15% saving (overall average) when using the more soil-friendly (loosening) technology, whereas for strip-till the same value was 30%, resulting in a difference in fuel use per hectare of grain yield (assuming the same yield levels) of more than 5 litres/tonne, which is more than 40 litres/ha even at an average yield level.

In the current economic climate, with rising production costs, high crop prices and yield depression (yield side losses) due to extremely dry weather, the success of certain crops may depend on the amount of fuel used in the implementation of the technology.

The study also included a measurement and comparison of the labour time input per hectare of the cultivation technologies. In terms of operational characteristics, there was no significant difference in area performance for different soil types for a given technology:

- for strip tillage: 2.8-3.3 ha/h,
- 2.5-2.9 ha/h,
- ploughing: 1,5-1,6 ha/h.

Compared with conventional ploughing-based technology and strip-till technology, this represents a saving of more than 50% in working time. The difference is partly due to the reduction in the number of passes (combined operations) and partly to the efficiency gains resulting from the use of positioning systems and, in conjunction with this, automatic steering and the automation of certain technological operations (no overlap and no skip, section-controlled implement-machine linkages). If the analysis is carried out on a pre-sowing basis, it can be seen that, depending on the type of cultivation, the working time and thus the cultivation costs are reduced by around 11-14% for late pre-sowing.

By examining the relationship between the technology used and the specific input use, and measured in natural terms (fertiliser kg/ha, seed/ha, maize herbicide l/ha), it can be concluded that the use of precision technology resulted in input savings of between 5 and 10% compared to conventional technology, while specific yields were not reduced compared to the average of the AKI test farm.

Even higher savings can be achieved if the technology is extended to all crops in the rotation. Obviously, it is worth taking into account that a change in technology is associated with an increase in intensity, which is also reflected in higher yields, especially when a large proportion of the crops in the rotation are switched from dry to irrigated management.

Compliance with the GD is already partly ensured from a technological point of view, but the biggest challenge is still to meet food safety requirements and expectations, which for arable crop farmers means that the biggest change in the near future will be in crop protection.

In addressing the challenges as opportunities, the importance of foresight-based crop protection interventions should be emphasised, taking into account the opportunities offered by biological control and the changes and developments in chemical and mechanical weed control.

Forecast-based interventions are best supported by applications and web-based interfaces that process and analyse data from meteorological stations and complement them with pathogen and pest forecasts.

The justification and timing of interventions have a major impact on the effectiveness and success of the technological intervention, as well as on the amount of pesticide applied and the total amount used in the whole production technology. Repeated interventions due to unwarranted or poorly timed interventions result in additional expenditure, making it difficult to meet the quantitative targets set out in the Farm to Fork strategy.

In the biological pesticides market, a number of R&D and manufacturing agreements have been concluded in recent years and tens of mergers, acquisitions and joint venture agreements have been implemented. With the agrochemical giants spending an estimated hundreds of millions of dollars a year on development, biological solutions are slowly but surely emerging for a growing number of pests and pathogens, while weed control is still relying on conventional chemical solutions or mechanical weed control. For example, biological fungicides are now available, or biological fungicides are increasingly being used effectively against fusarium aphid in cereals, with the same efficacy as chemical products, and can therefore fully replace chemicals. However, the replacement of pesticides used for postemergence weed control in maize by biologicals is not yet feasible, leaving the use of row crop cultivators as an alternative to chemicals.

The amount of pesticide used and applied is strongly influenced by the method of application and the technical and technological development of the machinery and equipment used for application. The emergence of drones opens up new horizons, both in terms of pre-application surveys and application, which also makes it possible to achieve savings of up to 20% in kind.

The latest precision sprayers, whether self-propelled or towed, are equipped with sensor cameras under the banner of "smart spraying", capable of detecting and distinguishing between crop and weeds, so that they only apply herbicide when the sensor camera passing over the weed signals the sprayer nozzles, allowing a 50% reduction in the dose of herbicide used or applied compared to a conventional sprayer.

In the field of mechanical weed control, new methods and machines have also emerged in the last few years, so the use of laser weed control, weed killers and weeding robots, which still seem futuristic, could be an alternative to chemical weed control.

All in all, a key condition for the implementation of the European Green Deal and its strategy for agriculture, which will have an impact on it, is that all the players in the sector are aware that meeting the challenges requires systems thinking and documentation.

A systems approach is understood to mean the principles of precision farming, which in the case of conventional arable crops are: right time, right place, right amount, right materials, right tools, right method.

As all technological interventions can be documented by artificial intelligence in machines, newer and newer IT solutions, the use of applications for the digital transformation of agriculture, the use of the internet, the only question is how quickly can we meet the challenges of the future? Namely, the fact that production is essentially determined not by yield expectations but by sustainability standards. This is partly the reason for the rise in production costs and the concomitant increase in the need for expertise and knowledge of decision support systems. And the authors of this study are happy to note that a deep interest in information technology is, after all, a concomitant of technological development and increased efficiency, whether natural or economic!

SUMMARY

Many of the forecasts presented in this paper, in part or in full, give contradictory results. Some argue that in the F2F strategy proposed by the European Commission, the given input reductions would lead to a reduction in EU agricultural production and competitiveness in export markets. According to these reports, under the current agricultural production process, changes resulting from reduced use of agricultural inputs in the strategies would lead to higher food prices, lower consumer and therefore consumption, and, strange as it may seem, lower GDP.

Our first assumption that "the GD and F2F strategies can be implemented without problems and without losses" is not correct and cannot be accepted. They are confirmed by the results of the model calculations presented in the secondary research. The impact mainly affects EU Member States, predicting a decline in GDP and economic welfare and well-being.

Seeing the increase in input prices and overheads, which are now global and have an impact on the direct and indirect costs of agricultural production as well as on the food industry, coupled with a prolonged dry period in 2022 in several European countries, we forecast a dramatic increase in food prices. At the time of writing, we had not even considered that a seemingly bilateral (Russia-Ukraine) war would have global impacts. What effects might this have? In our view, even without restrictions, there could be temporary, local and even product-specific shortages in market access for a particular product. We do not want this to happen.

A shortage of supply can lead to price increases at the same level of demand, since for basic foodstuffs, meeting demand from imports has a price-driving effect. As well as slowing supply chains, the cost of overseas and inland transport has risen significantly over the past few years due to rising energy prices, and energy prices are set to spiral out of control from 2021. The second assumption, A2, which was that "the know-how solutions and the technological conditions for precision agriculture that are currently available are already in place, and that all these factors together already confirm the feasibility of assumption A1", is a cross-cutting issue. We must acknowledge that this is not true. More knowledge, techniques and technologies are already available to support the objectives and expectations of DG and F2F. However, a large "group" of "necessary conditions" is missing from the repository of feasibility. The conditions are also composed of several segments: political conditions, macro- and micro-economic conditions, corporate-financial, but also, and emphatically, human resource conditions in addition to all economic conditions.

Among the studies, we found one source (Beckman et al., 2021) that examined the amount of agricultural productivity growth that would be needed to compensate for input limitation. Evidence from the empirical literature suggests that it would take 2-3 times the 10-year period of strategies to develop and transition to new technologies. In this context, while avoiding production losses and food price increases, the only way to achieve the expected reduction in input use is to make the necessary investments in the short term and to extend the timeframe by 10-20 years. As the study points out, it may be worthwhile to make the necessary investments as soon as possible to facilitate the introduction, dissemination and widespread use of modern, efficient technologies. Thus, it is worth targeting support for investments in precision technologies, the services, training, knowledge transfer, forward-looking development and research needed to use them, as further increases in input, labour and other costs are expected in addition to sector-independent energy increases.

In addition to the successive price increases (which are reflected in almost all cost items), the direct efficiency gains induced by the short payback investments in subsidised crops will allow the use of modern crop-specific cultivation technologies adapted to the needs of the crop, aiming at yield maximisation. If the maintenance or increase in specific yields is combined with cost efficiency, the sector's performance, profitability and competitiveness will improve. Higher consumption and increased investment will boost the contribution of growing exports to GDP. This will reduce the EU's dependence on food imports, while reducing the amount of inputs and chemicals used through the application of sustainable, modern and environmentally sound technologies. This will also reduce the direct and indirect environmental impact, in particular in terms of air pollution, as the unit of agricultural output will be produced with less and less carbon dioxide emissions.

The benefits of the strategies for the environment and human health are a subject of ongoing debate in the literature, mainly because of the way in which the environmental costs and benefits associated with the strategies are measured. The modellers noted that the changes estimated therein are based on large structural policy shocks, but could not have anticipated that Covid would still constrain market processes, could not have anticipated that the Russian-Ukrainian war would override sustainability and energy management policies, and could not have anticipated that global climate change would come drastically to European countries in 2022.

Strategists have introduced incentives to adopt new technologies and innovations. It is assumed that the adoption of these technologies will help to mitigate the productivity impacts of the input reductions introduced by the strategies. Although the details of these targets are not fully defined, they deserve more attention. However, current high-technologies are unlikely to be sufficient to compensate for the production losses resulting from the magnitude of the reductions in agricultural inputs. A de facto treadmill of agricultural technology adoption, together with insufficient R&D stocks and spending, pose clear challenges for future productivity growth and feeding a growing population. This raises concerns about the feasibility of EU strategies in the proposed roadmap and the consideration of the steps needed to create a more sustainable food and agriculture system.

As a final reflection, we believe we can agree with Beckman and colleagues' view that ultimately a strong and resilient food system can benefit from greater investment in innovative agricultural R&D. Where, ultimately, sustainability is achieved through continuous adaptation to new and unique challenges through science, innovation and adoption by farmers in their own fields around the world (Beckman et al., 2021). However, we also see that there is a huge challenge in agriculture. It will take hundreds of people from universities, research institutes and agribusinesses to meet the challenges and make a living from agriculture in the next decade, if at all!

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