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Transforming the grapevine world through new breeding techniques

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Abstract. This paper analyses the drivers and barriers to grape growers' intention to adopt New Breeding Techniques (NBT) in viticulture. The research approach is based on in-depth interviews, a method chosen to collect rich, qualitative information and elicit grape growers' beliefs towards NBT and opinions about genome modification (GMO). The specific aim is to identify the drivers and barriers to their adoption. The interviews were administered to participants from six European countries (Italy, France, Spain, Portugal, Greece, and Hungary), ensuring a diverse and comprehensive perspective. The outcome provides a robust understanding of what stakeholders think about biotechnology applied to grapevine. This analysis reveals the stakeholders' views on the main obstacles and benefits of introducing grapevine resulting from NBTs in their cultivation, instilling confidence in the research process's thoroughness and the results' reliability.

1. Introduction

In our contemporary society, we are faced with urgent challenges related to climate change and food security. Extreme weather events and rising temperatures in specific regions significantly hinder traditional crop cultivation. Simultaneously, the growing global population requires a proportional increase in food production, which can be met by improving crop yields. In this context, recent advancements in formulating regulations for New Genetic Technologies, also known as new breeding techniques (NBTs), as outlined in proposal COM (2023) 411 final [1], offer hope by underscoring the potential benefits of agricultural science advancements.

In recent decades, extreme events, higher temperatures, and changes in precipitation patterns have hurt grape yield and quality [2]. Furthermore, according to the latest report on pesticide residues in food published by the European Food Safety Authority [3], wine grapes are among the processed food samples with the highest frequency of multiple pesticide residues.

In viticulture, NBTs offer a promising avenue for applying scientific advancements. NBTs consist of a wide array of techniques, many allowing for genome corrections without the need for DNA manipulations or altering the plant's genetic heritage. These techniques address challenges in wine production by enhancing plant resistance to parasites, diseases, and extreme climatic events such as heavy rainfall or prolonged drought. This, in turn, reduces the dependency on agrochemicals and fosters better adaptation to climate change. NBT products have the potential to enhance the resilience and sustainability of agri-food systems, aligning with the innovation and sustainability goals outlined in the European Green Deal and Farm to Fork Strategy [4].

In the European Union (EU), the legal framework for approving, overseeing, and labelling genetically modified organisms (GMOs) and genetically altered goods has existed since 2001, according to Directive 2001/18/EC [5]. Nonetheless, the European law has been revised in response to current developments in genome engineering. The European Commission was requested by the Council of the European Union on November 8, 2019, to conduct a study that would elucidate the consequences of NBTs. The study emphasises how some NBTs (mutagenesis and cisgenesis) differ from conventional genetic modification (GMO) methods in that they do not include the insertion of foreign genetic material from other organisms. Because of this, organisms created using these NBTs may resemble or even be identical to those produced by traditional breeding. The study's primary finding is that the EU's

GMO laws cannot cover plants developed using these methods.

Given the study's result, in July 2023, the European Commission proposed a New Regulation on plants produced by certain NBTs [1], later approved by the European Parliament on 7 February 2024. The proposal suggests the exemption from regulations on GMOs of Category 1 NBT plants, defined as plants that contain genetic material from the same plant (targeted mutagenesis) or crossable plants (cisgenesis, including intragenesis); transgenic plants (which contain genetic material from non-crossable species) will remain subject to the GMO legislation as it stands today.

The topic of NBTs is explored in the socio-economic literature, with studies focusing on consumer perception and acceptance. Consumers' apprehension toward biotechnologies is influenced by public opinion [6], [7], [8], [9] . It is crucial to enhance understanding of the benefits of new technologies, highlighting their close relationship with environmental sustainability. It is essential to show that innovation and tradition can complement each other in promoting and safeguarding agricultural production in quantity and quality. Furthermore, government decisions to prohibit or approve GM crop cultivation significantly affect consumer responses. Public support increases when the potential benefits of the technology are communicated, thus fostering increased trust in the government and belief in science [10]. The societal stigma surrounding GM foods, such as neophobia and perceived health risks from innovative technologies, often shapes consumer perceptions of these products. There is a tendency for individuals with a high level of education to overestimate consumers' actual knowledge, potentially leading to lower acceptance of GM foods [10].

This paper's novelty is related to its analysis of the supply side knowledge, perception, and acceptance of GMO and NBT in six EU countries (Italy, France, Spain, Hungary, Greece, and Portugal). Our analysis identified the main obstacles and driving factors influencing the adoption of NBTs in viticulture.

2. Methodology

2.1. Survey design

After introducing the main topic, we delved into a detailed analysis of a case study. This study was based on original in-depth interviews conducted with 18 European grape producers from six countries, namely Italy, France, Spain, Portugal, Greece, and Hungary. These countries were specifically chosen due to their significant roles in the wine industry, representing 83% of Europe's wine production and 53% of the world's wine production in 2023. The primary aim of the interviews was to gain insights into the producers' views on both GMOs and NBTs and gauge their level of acceptance and knowledge of these technologies. Data was collected between May and July 2024, with interviews being conducted in person or online via the Teams platform. This article covers the analysis of data from the following questions:

1. What do you think about genome modification (GMO) applied to grapes and vines?
2. What do you know about New Breeding Techniques (NBT) applied to grapes and vines?

This study examined open-ended responses regarding GMOs and NBTs. Participants were provided with the definition of what NBT are, and they were asked to express their thoughts and opinions. The study analysis was carried out by following these steps: 1) textual analysis; 2) identification of keywords for barriers and attractors/benefits/advantages; 3) classification of producers' perceptions concerning GMOs and NBTs based on the keywords found. All interviews were transcribed to then proceed to textual analysis. As for data analysis, we reported the respondents' answers in Excel by going to create a dataset. From this dataset, we decided to extrapolate keywords with positive, neutral, and negative attributes (decreased biodiversity, ethical issues, resistance to pathogens, higher yield, climate change) from each response to understand the experts' opinions and highlight the perceptions of the two genetic technologies.

We apply content analysis, studying word frequency and co-occurrence, to uncover the underlying meaning embedded in the text. This method allows us to better understand the content by identifying patterns and relationships among words. Two matrices were generated using the survey responses based on word co-occurrence, one for each topic for the eighteen participants. The essential data set is an n×m matrix **S**, where n equals the words in the analysis and m is the number of respondents, with words converted in attributes reporting a frequency above the mean (positive and negative attributes=3) (Figure 1). The two mirror matrices differ concerning the attributes assigned to the old techniques (GMOs) and new genetic modification techniques (NBTs). This differentiation was required to assess the perception and acceptance levels regarding the two methods. The summary analysis is presented with graphical representations depicting the sentiments of consumers and their corresponding attributes: positive, negative, neutral, and "I don't know". However, the last two attributes, "neutral" and "I don't know", were merged into a single category labelled as "I don't know". This adjustment provided a more precise and more accurate representation of consumer sentiments.

Table 1. S matrix for words occurrence.

	Farmers' Perception		
Acceptance		ID1	ID2
	Negative		
	I don't know		
	Positive		

3. Results and discussions

3.1. Results on GMO farmers' perception

In this section, we examine how producers perceive GMOs and NBTs by identifying the obstacles and benefits of using these techniques. The analysis shows a variety of reasons for opposition to GMOs, such as the inclusion of foreign traits in plants, loss of biodiversity, and high costs. However, most respondents hesitate to use these techniques due to ethical concerns and their potential impact on biodiversity (Figure 1).

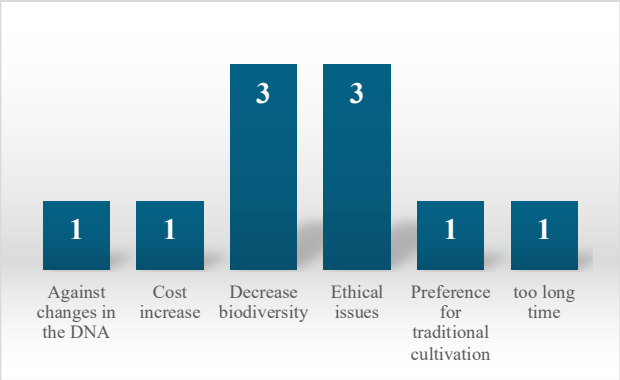

Figure 1. Negative Attributes of GMOs.

Many respondents are sensitive to ethical issues and the decline in biodiversity associated with GMOs. This aligns with empirical evidence highlighting a reluctance to embrace GMO practices deemed less safe than conventional methods. Numerous studies across various disciplines, including economics, sociology, and moral psychology [8], [10], [11], suggest that public attitudes toward GMOs are influenced more by individual values and moral traditions than scientific evidence. When comparing the negative attributes with the positive ones, climate change and pathogen resistance drive the good feelings. This seems to bring about a fundamental contradiction in the purpose of GMOs, which appears to be gaining consensus on the issues at the heart of applications related to combating climate change by going beyond the ethical question. This is particularly interesting because the moral concerns of plant genetic modification consist of transmitting alien genes into food and causing a food safety crisis [11]; thus, the environmental impact of GM plants is a primary ethical concern. On the other hand, literature has been very concerned with supporters and opponents of GMOs in recent decades, investigating topics ranging from social psychology to political economy. What many authors note is the idea that ethical concerns drive opponents of GMOs. Overcoming the problems behind the non-acceptance of GMOs may become instrumental in solving the significant challenges the world will face in the future. Farmers raised additional concerns regarding potential risks linked to the perceived naturalness of genome editing [12].

The recurring positive attributes highlighted in the previous discussion relate to the plant's ability to resist pathogens and adapt to climate change, which are essential factors in sustainable agriculture. These attributes serve as a basis for addressing another critical concern, namely the reduction of pesticide use (Figure 2). Climate change and pathogen resistance are sensitive issues for farmers/stakeholders. This sensitivity could be influenced by their current challenges, namely the increasing extreme weather events, which require producers to put more effort into managing product losses.

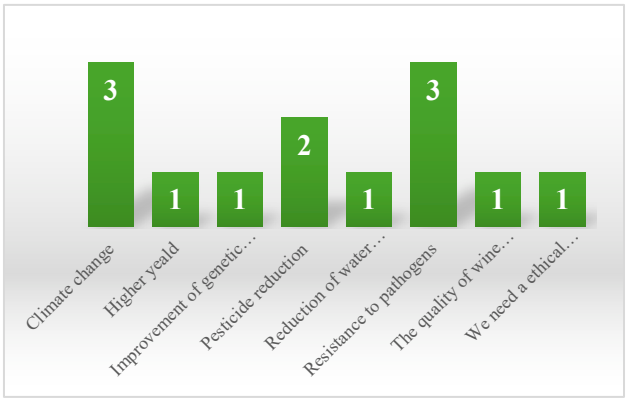

Figure 2. Positive Attributes of GMOs.

3.2. Results on NBTs farmers' perception

Regarding the analysis of NBTs, we can claim certain consensus on the concepts that could be considered as opportunities, such as drought resistance, water consumption reduction, decrease in pesticide use, and consequently, cost reduction. Interview findings highlight a certain degree of consensus on the negative attribute concerning decreased biodiversity; this result is shared between the two categories of techniques analysed, while among the positive attributes, the most frequent keyword is 'cost reduction' (Figures 3 and 4).

This summary helps to understand the general trend in respondents' perceptions of GMOs and NBTs, providing a clear overview of their opinions and concerns. Biodiversity also seems to be the dominant feature in NBTs [13]. The ethical aspect of NBTs appears to be outdated, while biodiversity remains. In this sense, the literature shows that the acceptance of NBTs seems more remarkable since, with these techniques, one overcomes the introduction of external traits in the plant.

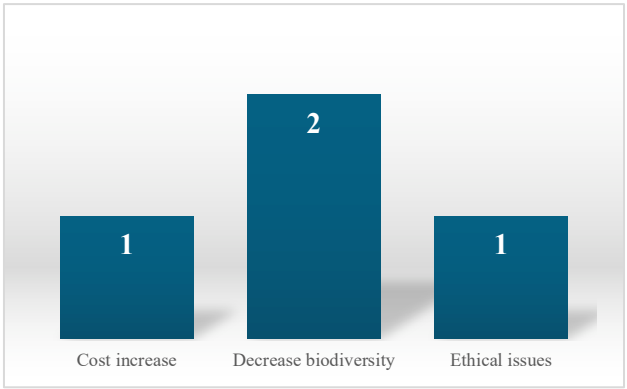

Figure 3. Negative Attributes of NBTs.

Various studies have documented that acceptance of new technologies depends on perceptions of their risks and benefits [14], [15], [16], [17]. How people perceive risk involves more than just looking at the facts and understanding the science behind it. It also includes personal feelings, emotions, and ethical considerations related to religion and culture [18]. Many people who hold negative opinions about genetically modified foods often lack knowledge about the technology, do not trust the developers or the effectiveness of regulations, and have concerns about the risks, benefits, and ethical implications [19], [20], [21], [22]. In addition, biotechnologies hold significant promise in advancing sustainable agri-food systems that align with the objectives of the European Green Deal and the Farm to Fork Strategy. This can be accomplished by fostering synergies between agricultural practices and environmental conservation, as well as by enhancing the efficiency and productivity of the farming and food sectors [23], [24], [25]

Adopting new agricultural technologies raises questions regarding the economic costs and benefits, as well as the impact on agricultural structure. According to Klerkx and Rose [26], these technologies, alongside other advancements in machinery and digital technology, could shape the future of agriculture [27]. . Farmers seem to emphasise perceived economic benefits, usually in reduced chemical inputs and cost reductions. Future message strategies should focus on the potential economic benefits of NBTs[28].

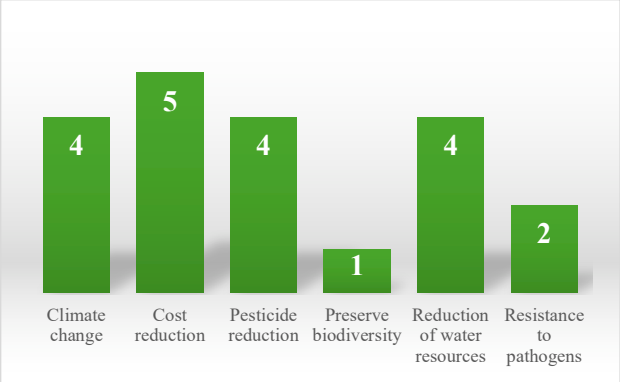

Figure 4. Positive Attributes of NBTs.

4. Conclusion

This study aims to contribute to the literature by providing additional information on producers' opinions in six EU countries on the opportunities and challenges of grapevine obtained through NBTs and on the level of consensus between experts belonging to different supply chain segments. To this extent, we conducted structured interviews to collect opinions and data. Their opinion is relevant because it provides an alternative point of view on the desirability of implementing NBTs; additionally, an open insight into the perceived legitimacy of decisions is also allowed. Moreover, stakeholders play a crucial role in identifying overlooked factors and considerations, which in turn contribute to enriching the economic, social, and environmental discourse. As such, it is ideal for stakeholders to be actively involved in prioritising research efforts. Results somehow reveal convergence across methods and key distinctions in constructing consensus and oppositions about using NBTs or GMOs in grapevine. All respondents express a standard view that should guide researchers in analysing the studies and behaviours at the centre of their research, on the one hand, and policymakers, on the other, to guide future programming choices.

The lesson we can learn is that the quality of information, specifically the information provided by the scientific community, should guide the acceptance of wines from NBTs.

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6. References

1. *COM(2023) 411 final*. [Online]. Available: https://eur-lex.europa.eu/legal-content/IT/TXT/HTML/?uri=CELEX:52023PC0411
2. R. Gutiérrez-Escobar *et al.*, 'Development and characterization of a pure stilbene extract from grapevine shoots for use as a preservative in wine', *Food Control*, vol. 121, p. 107684, Mar. 2021, doi: 10.1016/j.foodcont.2020.107684.
3. E. F. S. Authority (EFSA), 'Plant Health Newsletter on Horizon Scanning–December 2023', *EFSA Support. Publ.*, vol. 20, no. 12, p. 8524E, 2023, doi: 10.2903/sp.efsa.2023.EN-8524.
4. European Commission, *SWD(2021) 92 final*. [Online]. Available: https://food.ec.europa.eu/document/download/5135278b-3098-4011-a286-a316209c01cd_en?filename=gmo_mod-bio_ngt_eu-study.pdf.
5. *EU Directive 18*. 2001. Accessed: Jul. 26, 2024. [Online]. Available: https://eur-lex.europa.eu/eli/dir/2001/18/oj
6. E. J. Van Loo, V. Caputo, and J. L. Lusk, 'Consumer preferences for farm-raised meat, lab-grown meat, and plant-based meat alternatives: Does information or brand matter?', *Food Policy*, vol. 95, p. 101931, Aug. 2020, doi: 10.1016/j.foodpol.2020.101931.
7. I. M. Sheldon, 'Regulation of biotechnology: will we ever "freely" trade GMOs? | European Review of Agricultural Economics | Oxford Academic', *Eur. Rev. Agric. Econ.*, vol. 29, no. 1, pp. 155–176, 2002, doi: https://doi.org/10.1093/erae/29.1.155.
8. M. Qaim, 'Role of New Plant Breeding Technologies for Food Security and Sustainable

Agricultural Development', *Appl. Econ. Perspect. Policy*, vol. 42, no. 2, pp. 129–150, 2020, doi: 10.1002/aepp.13044.

9. M. Bunge, *Critical Approaches to Science and Philosophy*. Routledge, 2018.

10. R. Sendhil *et al.*, 'Genetically modified foods: bibliometric analysis on consumer perception and preference', *GM Crops Food*, vol. 13, no. 1, pp. 65–85, 2022, doi: 10.1080/21645698.2022.2038525.

11. G. Bhardwaj, J. C. Camillus, and D. A. Hounshell, 'Continual Corporate Entrepreneurial Search for Long-Term Growth', *Manag. Sci.*, vol. 52, no. 2, pp. 248–261, Feb. 2006, doi: 10.1287/mnsc.1050.0477.

12. M. Robbins, C. Calabrese, J. D. Featherstone, and G. A. Barnett, 'Understanding knowledge and perceptions of genome editing technologies: a textual analysis of major agricultural stakeholder groups', *J. Sci. Commun.*, vol. 20, no. 5, p. A07, Sep. 2021, doi: 10.22323/2.20050207.

13. F. Bohle, R. Schneider, J. Mundorf, L. Zühl, S. Simon, and M. Engelhard, 'Where does the EU-path on new genomic techniques lead us?', *Front. Genome Ed.*, vol. 6, Mar. 2024, doi: 10.3389/fgeed.2024.1377117.

14. J. F. Siler, *The House of Mondavi: The Rise and Fall of an American Wine Dynasty*. Gotham Books, 2007.

15. L. J. Frewer, A. R. H. Fischer, and J. (Hans) C. M. van Trijp, 'Communication of Risks and Benefits of Nanotechnology: the Issue of Societal Acceptance of Emerging Technologies', in *Nanotechnology in the Agri-Food Sector*, John Wiley & Sons, Ltd, 2011, pp. 243–256. doi: 10.1002/9783527634798.ch14.

16. E. M. Rogers, A. SINGHAL, and M. M. QUINLAN, 'Diffusion of Innovations', in *An Integrated Approach to Communication Theory and Research*, 2nd ed., Routledge, 2008.

17. A. Vishwanath and G. A. Barnett, *The Diffusion of Innovations*. 2021. Accessed: Sep. 11, 2024. [Online]. Available: https://www.peterlang.com/document/1108573

18. P. Slovic, 'Perception of Risk', in *The Perception of Risk*, Routledge, 2000.

19. J. M. Lucht, 'Public Acceptance of Plant Biotechnology and GM Crops', *Viruses*, vol. 7, no. 8, Art. no. 8, Aug. 2015, doi: 10.3390/v7082819.

20. M. Siegrist, 'A Causal Model Explaining the Perception and Acceptance of Gene Technology', *J. Appl. Soc. Psychol.*, vol. 29, no. 10, pp. 2093–2106, 1999.

21. A. Keller *et al.*, 'New insights into the Tyrolean Iceman's origin and phenotype as inferred by whole-genome sequencing', *Nat. Commun.*, vol. 3, no. 1, p. 698, Feb. 2012, doi: 10.1038/ncomms1701.

22. S. Wunderlich and K. A. Gatto, 'Consumer Perception of Genetically Modified Organisms and Sources of Information', *Adv. Nutr.*, vol. 6, no. 6, pp. 842–851, Nov. 2015, doi: 10.3945/an.115.008870.

23. L. Ferrari, 'Farmers' attitude toward CRISPR/Cas9: The case of blast resistant rice', *Agribusiness*, vol. 38, no. 1, pp. 175–194, 2022, doi: 10.1002/agr.21717.

24. F. DeMaria and A. Zezza, 'Scientific information and cognitive bias in the case of New Breeding Techniques: exploring Millennials behaviour in Italy', *Ital. Rev. Agric. Econ. REA*, vol. 77, no. 2, Art. no. 2, Aug. 2022, doi: 10.36253/rea-13676.

25. R. Lassoued, D. M. Macall, S. J. Smyth, P. W. B. Phillips, and H. Hesseln, 'Risk and safety considerations of genome edited crops: Expert opinion', *Curr. Res. Biotechnol.*, vol. 1, pp. 11–21, Nov. 2019, doi: 10.1016/j.crbiot.2019.08.001.

26. L. Klerkx and D. Rose, 'Dealing with the game-changing technologies of Agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways?', *Glob. Food Secur.*, vol. 24, p. 100347, Mar. 2020, doi: 10.1016/j.gfs.2019.100347.

27. S. Lemarié and S. Marette, 'The socio-economic factors affecting the emergence and impacts of new genomic techniques in agriculture: A scoping review', *Trends Food Sci. Technol.*, vol. 129, pp. 38–48, Nov. 2022, doi: 10.1016/j.tifs.2022.07.013.

28. K. Doxzen and H. Henderson, 'Is This Safe? Addressing Societal Concerns About CRISPR-Edited Foods Without Reinforcing GMO Framing', *Environ. Commun.*, vol. 14, no. 7, pp. 865–871, Oct. 2020, doi: 10.1080/17524032.2020.1811451.