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Commentary

New genomic techniques in organic production: Considerations for science-based, effective, and acceptable EU regulation

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The EU has a goal of 25% organic farmland by 2030, but lower yields in organic farming versus non-organic farming puts strain on sustainable food production. Utilizing new genomic techniques (NGTs) in organic production could improve yields. However, NGTs are currently banned in the EU organic production rules, and we advocate that incorporating NGTs into organic production with participatory governance will help achieve the EU's sustainable agriculture goals.

The 2025 European Union (EU) vision for agriculture and food affirms the European Commission's (EC) commitment to continuous support for organic farming. In the framework of the European Green Deal, the EC has set the political goal to achieve at least 25% of the EU's agricultural land under organic farming by 2030. In 2022, 10.5% of the total utilized agricultural area in the EU was farmed organically. However, lower yield production of organic farming compared to conventional production significantly decreases its overall environmental performance, especially when evaluating the environmental footprint per unit of output.[1,2] Meta-analyses of studies using data from plot trials or from scientifically supervised comparable farms suggest that mean organic yield gaps are in a range of 15%–20%, meaning that more land is required to produce the same amount of food. Research has shown that the target of 25% organic land is unlikely to ensure sustainable food production in the EU if modern biotechnology, such as new genomic techniques (NGTs), is excluded from organic farming.[1,3] However, a faster translation of research in plant breeding, including NGTs, into crops available to farmers for cultivation in the EU has been shown to increase agriculture productivity in the EU, including the organic sector.[4]

Organic farming within the EU under the EU Organic Production Regulation (EU) 2018/848 is currently precluded from leveraging advancements in modern biotechnology to enhance yields, which includes the use of most genetically modified organisms (GMOs) (defined in EU Directive 2001/18/EC as "organisms [...] in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination") but also concerns NGTs. The prohibition of GMOs in organic production is not unique to the EU but consistent in all organic practices and regulations across the world.[5] However, the definition of GMOs, and whether GMOs encompass NGTs, varies worldwide and as such, their treatment in the practice of organic production varies as well.[6] Under the existing EU GMO rules, NGT crops are considered GMOs and therefore subject to the same regulatory requirements.

In 2021, the EC's "Study on the status of NGTs under Union law and in light of the Court of Justice ruling in case C-528/16" concluded that EU GMO laws are no longer fit for purpose due to advances in plant breeding. As a result, the European Council requested a proposal to regulate NGT plants, which was published in July 2023 (hereinafter referred to as the proposal) and is currently undergoing the legislative process. In the proposal, NGTs primarily refer to techniques of targeted mutagenesis (a genetic technique that creates precise changes in an organism's DNA at specific locations without introducing foreign genetic material) and *cis*-/intragenesis (a transfer of a gene or rearrangement of genetic material, respectively, from the same or a sexually compatible species). Consequently, the proposal does not cover other types of NGTs, such as transgenesis, a technique transferring foreign (including non-plant) DNA into targeted cells. The proposal distinguishes between NGT-1 plants that could occur naturally or through conventional breeding and NGT-2 plants. The proposed equivalence criteria, based on the type, size, and number of genetic modifications, including the number of nucleotides involved (the molecular building blocks of DNA or RNA), will determine whether an NGT plant is considered equivalent to naturally occurring or conventionally bred plants, or whether it is considered an NGT-2 plant. If the proposal is adopted, all NGT plants will remain classified as GMOs; however, their regulatory requirements will change: NGT-1 will be regulated similarly to conventionally bred plants, whereas NGT-2 plants will be subject to existing EU GMO rules, with certain exceptions. This creates a paradoxical situation: although the application of EU GMO rules to NGT-1 plants is proposed to be lifted and partially lifted with regard to NGT-2 plants, the proposal still prohibits NGT-1 and NGT-2 plants and food and feed derived therefrom in organic production. This legal paradox is explained by the EC's view that NGTs are incompatible with the current concept of organic production and consumers' perception of organic products.

This comment advocates for permitting the use of NGTs in organic farming, aligning it with their acceptance in conventional agriculture. Organic and conventional farming share broad sustainability-oriented plant-breeding objectives irrespective of the breeding technology used. The use of NGTs in organic production can further contribute to the EU's sustainable agriculture. To foster broader acceptance and integration of NGTs within the organic farming community, participatory governance in organic production, including plant breeding, should be implemented.

Science-based regulation

Improvements in sustainable agriculture, such as higher yields, stress tolerance, resource efficiency, or effective plant nutrient supply, have become a vital objective in plant breeding, irrespective of whether organic, conventional, or NGT.[3] Both organic and conventional plant varieties are permitted in organic farming. While the priority is given to varieties bred for the specific needs of organic agriculture, most genotypes used in organic certification systems still originate from conventional breeding programs. The EU Organic Production Regulation characterizes organic varieties as having "a high level of genetic and phenotypic diversity between individual reproductive units" resulting from breeding activities "conducted under organic conditions." However, the same outcome can be achieved with NGT breeding: once the relationship between a trait (any morphological, physiological, biochemical, anatomical, or phenological characteristics of plants, such as plant height or disease resistance) and its genetic underpinnings is established, NGTs can be used to tailor the trait to environmental requirements and transfer it across varieties.[7] Successful breeding for important traits depends on the available genetic variation. NGTs offer unprecedented potential to create such diversity if gene identity, sequence composition, and allelic contribution, i.e., the effects of different gene variants, are known. Numerous pathways controlling important agronomic traits have been identified. New alleles of crucial genes in these pathways can be easily generated to expand the range of phenotypes breeders can choose from. However, uncertainties remain: for example, gene-editing tools that rely on natural proteins are limited in their editing capabilities and require extensive, precise customization.[8]

Recent studies have assessed the costs and benefits of organic farming and concur on the importance of new crop varieties.[9] NGTs, which allow very precise gene editing, have immense potential to increase the scope, speed, and precision of plant breeding[10] urgently needed to develop new crop varieties for organic farming.[2] The capability to precisely modify single genes in established genotypes significantly reduces the need for time-intensive backcrossing, a type of conventional breeding strategy, and allows the continued use of established varieties in cross-pollinated crops. Editing single genes in maize, such as *ZmAbh4*, which encodes the enzyme abscisic acid (ABA) hydroxylase 4 involved in controlling steady-state levels of the plant hormone ABA, can significantly increase water-use efficiency, as ABA plays a significant role in reducing plant transpiration under drought, cold, or salt stress.[11] Another example is the editing of gene promoters for sugar will eventually be exported transporter (SWEET) proteins, which transport sugars—including those exploited by invading pathogens. In rice, such editing has been shown to confer broad-spectrum resistance to bacterial leaf blight.[12] Many other approaches have advanced significantly, as targeting of a single gene is frequently effective.[13] The inactivation of susceptibility genes, the presence of which increases the likelihood of developing a particular disease, remains one of the most straightforward approaches. More advanced techniques aim for subtle changes in disease-resistance genes to combat the inevitable evolution of novel pathogenicity factors.[13] Such traits are especially important for organic farming as they facilitate integrated pest management.[14] Early genome-editing breakthroughs have achieved durable resistance and entered pipelines of CGIAR, a global partnership financing most innovative agricultural research, enhancing neglected crops and promoting agrobiodiversity for smallholder farmers.[15] Gene editing is the best way to achieve short-term improvements of existing varieties, especially for cross-fertilizing and vegetatively propagated crops due to their long breeding cycles. This allows breeders to improve the gene pool, the total genetic information available in one species and other species with which it can be crossbred, using other breeding techniques, while buying time to control specific diseases.

Basing "organic + NGT" law on this evidence would make it both scientifically grounded and effective. A science-based regulation would carefully weigh the costs and benefits—including foregone benefits—of incorporating NGTs into organic production, drawing on the best available scientific evidence, which currently highlights a broad range of advantages of NGTs for plant breeding.

Effective regulation

In line with the EC proposal's risk-benefit approach to NGTs, two types of organic production could be created in the EU, either through market dynamics or legislature's fiat. For EU internal market regulation, we suggest that it appears more practical to have two regulated labeled schemes ("organic + NGT" and "organic − NGT") than to anticipate a member state exercising its legislative authority to introduce labeling schemes on ethical grounds or an emergence of unaudited private standards, both per the Regulation (EU) 1169/2011. If organic + NGT is to be introduced alongside the already existing organic − NGT scheme, an EU-wide regulation would provide better enforcement options by the state power coupled with private enforcement compared to a private standard alone. Exceptions in the existing regulations prove that bifurcating organic label is possible, although technical problems with identification and traceability remain. A way out could be to consider the adventitious or technically unavoidable presence of NGT organisms in organic production compliant with the GMO ban of the EU Organic Production Regulation, like the preceding Council Regulation (EC) no. 834/2007 and as currently established for conventional foods in the GMO Regulation (EC) no. 1829/2003: if NGT organisms are not identifiable, arguably, they are also technically unavoidable.[16] Without reliable identification methods that meet legal requirements, organic production incorporating NGTs emerges as the only effective option to be regulated at the EU level. In the absence of analytical identification methods, the organic − NGT scheme may depend entirely on enhanced traceability methods in tightly controlled supply chains facing similar trust and reliability issues as current organic production regarding GMOs. Only the costs and validation, auditing, and oversight of such methods will determine whether the exclusion of NGTs from organic production is achievable.

Acceptable regulation

Among the organic production movement, divergent perspectives emerge regarding the relationship between NGTs and organic production. One perspective argues that the holistic approach inherent in organic production is at odds with the adoption of NGTs. Advocates of this view maintain that the principles underpinning organic farming, such as the reliance on natural processes, are compromised by the introduction of NGTs. Societal organizations have expressed reservations toward company-driven and trait-based breeding methodologies.[17] Critics of NGTs contend that traits crucial to organic agriculture, such as abiotic stress tolerance, are complex and thus beyond the reach of current genome-editing technologies. Conversely, an opposing stance posits that NGTs hold promise in delivering superior crop varieties, thereby enhancing the resilience and productivity of agroecosystems. Proponents of this position hold that it is necessary to understand the nature of NGTs and to make nuanced distinctions between the technologies under consideration (GMOs versus NGTs). Significant progress has been made in understanding key molecular, cell, and biological principles and identifying relevant genes that can be targeted to develop traits suitable for organic farming. As recently demonstrated in maize, even complex traits, such as growth and organ size, can be targeted through systematic editing and crossing.[18] Accordingly, while there is a broader consensus among agrifood stakeholders in the EU on the potential benefits of NGTs—likely to grow as scientific evidence accumulates—disagreements on managing risks persist, often fueled by various interests that rely on sustaining public concerns about new technologies. Because perceptions of benefits and risks strongly shape public opinion on NGT crops, market and political positions may shift as public awareness of their potential advantages increases.

These developments and contrasting perspectives may call for a nuanced dialogue among the organic community to navigate the intersection of technological innovation, consumer acceptance of new technologies, and the pursuit of sustainability against the backdrop of advancing scientific knowledge. Participatory methods to governance, such as citizen's juries or food councils, gain traction as means to deliberate on regulatory or ethical questions, such as on the regulation of NGTs in the EU. The EC's Organic Production Action Plan also puts forward setting up EU networks of demonstration farms to promote participatory approaches. Such localized initiatives may contribute to the development of relevant organic + NGT solutions tailored to specific regional agroecosystemic conditions, thereby fostering sustainability. As such, integrating participatory governance solutions within the organic community alongside the new organic production rules carries the promise of ensuring broad acceptance of organic + NGT EU standards.

CONCLUSION

Organic agriculture can play an important role in the transition to more sustainable food systems, generating positive environmental and social impacts.[19] However, due to the significant yield gap compared to conventional agriculture, it needs a greater focus on efficiency and resilience. This can be achieved by introducing a greater diversity of crops, the development of which can be facilitated and accelerated by NGTs. Also, liberalizing NGT use in organic production could facilitate their integration into conventional agriculture as labeling and coexistence requirements would be reduced, lowering costs for all. Scientific research has long supported this change.[20] If organic agriculture is a promoted type of agricultural production in the EU, all forms of organic production (including NGT+) would need to be accepted when evaluating the reach of the organic targets in the EU. It is now up to European legislature to assess these scientifically informed arguments, enact an effective regulation on organic production and NGTs, and take the next bold regulatory steps.

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AUTHOR CONTRIBUTIONS

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DECLARATION OF INTERESTS

L.F. is an independent board member of Syngenta Group. K.P. is a member of Think Tank ImagineEuropa.

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