



AGRO-BIOLOGICAL POWER AND GLOBAL GOVERNANCE: THE STRATEGIC ROLE OF AGRICULTURAL BIOTECHNOLOGY IN CONTEMPORARY FOREIGN POLICY

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Article History

Received: 10.06.2025
Accepted: 27.08.2025
Published: 02.10.2025

Abstract: Agricultural biotechnology has transcended conventional agricultural policies over the past four decades, laying the groundwork for novel forms of power in international relations. This study analyzes the strategic role of agricultural biotechnology in contemporary foreign policy through the concept of agro-biological power, presenting a theoretical and analytical framework to reveal the transformative impact of biotechnology on international relations. Agro-biological power refers to the capacity of a state to create dependency relationships, set agendas, and export norms in the international arena through its agricultural biotechnology capacity, control over seed systems, authority to determine intellectual property regulations, and power to direct food supply chains. The central problematic of the research is to explain how and under what conditions agricultural biotechnology capacities enable states to generate effective agro-biological power in foreign policy. The research is designed as an analytical opinion article and conducted using qualitative methods. Official documents of international organizations, policy reports, and academic literature were systematically examined, and comparative analysis was performed through case studies of the United States, the People's Republic of China, and the European Union. The findings reveal that agro-biological power operates through four fundamental mechanisms: infrastructural dependency, normative hegemony, epistemic control, and crisis diplomacy. The impact of digitalization on agricultural biotechnology demonstrates that algorithmic decision support systems increase the effect of agro-biological power by making it invisible. The theoretical contribution of the study lies in developing the concept of agro-biological power by synthesizing biopolitics, power theories, and global governance literature, and conceptualizing agricultural biotechnology as a central component of international relations. At the policy level, it is recommended that developing countries strengthen their biotechnological autonomy and democratize global governance mechanisms.

Keywords: Agro-biological Power, Agricultural Biotechnology, Global Governance, Foreign Policy, Biopolitics, Epistemic Control, Normative Hegemony.

Cite this article:

Arslan, S., (2025). AGRO-BIOLOGICAL POWER AND GLOBAL GOVERNANCE: THE STRATEGIC ROLE OF AGRICULTURAL BIOTECHNOLOGY IN CONTEMPORARY FOREIGN POLICY. *ISAR Journal of Agriculture and Biology*, 3(10), 1-18.



1. INTRODUCTION

Agricultural biotechnology at the global scale has, over the past four decades, transcended conventional agricultural policies, laying the groundwork for the emergence of novel forms of power in international relations. Seed genetics, biosafety standards, intellectual property regulations, and data-based agricultural infrastructures have been transformed into strategic instruments that determine states' positions in the global system (Clapp, 2021; Howard, 2015). Particularly with the deepening of the climate crisis, the fragility of supply chains due to global pandemics, and the intensification of geopolitical competition, food security has been elevated to the category of national security, and agricultural biotechnology has become a new power dimension of foreign policy (Denning, 2023; Azariva, Brudny & Finkel, 2023). This transformation repositions agricultural biotechnology not merely as an instrument of economic efficiency, but simultaneously as a strategic domain that produces inter-state dependency relationships, determines norms and standards, and establishes epistemic sovereignty (Clark & Hobbs, 2024; Curry & Lorek, 2024). This study analyzes the strategic role of agricultural biotechnology in contemporary foreign policy through the concept of agro-biological power, presenting the transformative impact of biotechnology on international relations within a theoretical and analytical framework.

The concept of agro-biological power refers to the capacity of a state to create dependency relationships, set agendas, and export norms in the international arena through its agricultural biotechnology capacity, control over seed systems, authority to determine intellectual property regulations, power to direct food supply chains, and sovereignty over biological resources (Trauger, 2022). This concept transcends traditional definitions of power, focusing on power projection through biological infrastructures inherent in food and life processes (Resnick & Swinnen, 2024; Foucault, 2007; Lemke, 2011). The constitutive components of the concept are shaped along three main axes: Biological power emphasizes the form of modern authority's regulation of populations' life processes (Venkataram & Hefferon, 2023; Foucault, 2007); the geopolitics of food expresses the transformation of food production and trade into an arena of international competition (Lundgren, 2022; Patel, 2009; McMichael, 2013). Agro-biological power, by synthesizing these two theoretical strands, conceptualizes agricultural biotechnology not merely as a scientific activity but simultaneously as a strategic instrument that produces governance influence (Frerick, 2025).

Concrete indicators of the transformation in the field of agricultural biotechnology are observed in the structure of the global seed market. The commercialization of genetically modified organisms, which began in the post-1980s period (Howard, 2015; Clapp, 2018), has resulted not only in productivity increases but also in the restructuring of seed sovereignty and technological dependency relationships. Today, approximately seventy percent of the global seed market is under the control of a few multinational corporations; this situation brings consequences including the narrowing of seed diversity, the dependency of local producers on intellectual property regulations, and the centralization of agricultural production knowledge (Mahajan, Dhand, & Kaur, 2025). Patent regimes, biosafety protocols, and trade regulations are transforming agricultural biotechnology from a technical

domain into a political arena that shapes states' positions in the global governance architecture. In this process, technologically capable states establish epistemic sovereignty by determining not only the means of production but also knowledge production processes, security standards, and legitimacy criteria (Clapp et al., 2025).

The existing literature primarily addresses agricultural biotechnology from the perspectives of food security, productivity enhancement, and climate change adaptation capacity; the structural dimensions of biotechnology that produce power relations are insufficiently theorized (Janin, P. (2023). In the discipline of international relations, the concept of power is traditionally defined through military capacity, economic magnitude, and diplomatic influence; power relations established through biological infrastructures and knowledge regimes are overlooked (Nye, 2004). In the biopolitics literature, the emphasis on the governance of life predominantly focuses on population management, health policies, and forms of control over the body; the international dimension of food systems and agricultural biotechnology is insufficiently examined (Foucault, 2007; Lemke, 2011). The global governance literature discusses the role of international organizations and multilateral regulations; however, the processes by which the formation and dissemination of biotechnological standards reproduce power relations are not systematically analyzed (Held & McGrew, 2002; Rosenau, 1995). The first gap is the failure to conceptualize biotechnology as an independent source of power; the existing literature treats agricultural biotechnology as an economic activity or technical regulatory domain, insufficiently questioning how this field transforms inter-state power relations. The second gap is the insufficient theorization of epistemic control mechanisms; how the capacity to determine knowledge production processes and standards creates structural dependency, how it constrains policy choices, and how it establishes epistemic hegemony is not systematically explained. The third gap is the neglect of digitalization's impact on agricultural biotechnology; how genetic databases, algorithmic decision support systems, and bioinformatics infrastructures produce new forms of control; how biological power and digital power articulate is insufficiently discussed (Mahajan, Dhand & Kaur, 2025).

This study aims to fill the theoretical and empirical gaps identified above. First, by developing the concept of agro-biological power, the functions of agricultural biotechnology as an independent source of power are defined at the conceptual level. This concept synthesizes biopolitics theory's emphasis on the governance of life, power theories' analyses of influence and dependency, and global governance approaches' analyses of norm-setting. Second, epistemic control mechanisms are systematically explained; it is demonstrated how seed patents, biosafety standards, and genetic databases centralize knowledge production processes, through which mechanisms they constrain policy choices, and how they reproduce inter-state hierarchies. Third, the impact of digitalization on agricultural biotechnology is examined in relation to the concepts of algorithmic power and data sovereignty, and the articulation of biological power and digital power is analytically revealed. This synthesis, by integrating topics treated in a fragmented manner in the literature, conceptualizes agricultural biotechnology as a central component of contemporary foreign policy; it presents an original framework through theoretical

coherence, mechanism-centered explanation, and comparative analysis.

The purpose of the study is to theoretically develop the concept of agro-biological power and to explain the strategic role of agricultural biotechnology in foreign policy and the global governance architecture through a mechanism-centered approach. In line with this purpose, infrastructures that produce power and dependency relationships, the agenda-setting effect of norms and standards, and the modes of engagement of biological diplomacy instruments in crisis moments will be analytically disaggregated. The central problematic of the research is: How, through which mechanisms, and under which conditions do agricultural biotechnology capacities and governance instruments enable states to produce effective agro-biological power in foreign policy? This problematic opens into four research questions: First, which components of the agricultural biotechnology ecosystem create dependency and agenda-setting capacity? Second, at the global governance level, how does the export of norms and standards function as a strategic lever in foreign policy? Third, what are the foreign policy outcomes of biological diplomacy instruments during crisis periods? Fourth, how do digitalized agricultural infrastructures and algorithmic decision support systems create an articulation between biological power and digital power?

In seeking answers to these research questions, the study's four central hypotheses are formulated as follows: First hypothesis: As a state's agricultural biotechnology capacity increases, its power to set agendas and export norms in global governance arenas increases. Second hypothesis: States that determine knowledge production processes and standards structurally constrain the policy choices of importing countries and produce dependency relationships. Third hypothesis: In food and health crises, agricultural biotechnology instruments, beyond providing short-term assistance, establish long-term dependency relationships and increase diplomatic influence. Fourth hypothesis: Digitalized agricultural infrastructures, by combining biological power with data sovereignty, deepen the capacity for control and intervention.

These hypotheses point to four fundamental mechanisms of agro-biological power: infrastructural dependency, normative hegemony, epistemic control, and crisis diplomacy. The infrastructural dependency mechanism explains how seed technologies, genetic databases, and biotechnological research and development infrastructures structure inter-state dependency relationships. The normative hegemony mechanism reveals how biosafety standards, patent regulations, and trade agreements become global norms and how these norms shape the policy spaces of importing countries. The epistemic control mechanism demonstrates how the capacity to determine which knowledge is considered correct, which technology is safe, and which standard is legitimate produces power. The crisis diplomacy mechanism evaluates the foreign policy consequences of using agricultural biotechnology as a diplomatic instrument in food and health crises.

The expected contributions of the study are shaped at three levels: At the theoretical level, by developing the concept of agro-biological power, it synthesizes the literatures on power, biopolitics, and global governance; it presents an original conceptual framework that takes agricultural biotechnology beyond traditional power categories. At the empirical level, through case studies of the United States, the People's Republic of China, and

the European Union, it reveals in a comparative manner the strategies, mechanisms, and outcomes of states that use agricultural biotechnology as a foreign policy instrument. At the policy level, it presents policy recommendations necessary for developing countries to achieve strategic autonomy in the field of agricultural biotechnology; it discusses strategies for reducing technological dependency, building epistemic sovereignty, and effective participation in global governance processes.

2. LITERATURE REVIEW

The literature explaining the strategic position of agricultural biotechnology in international relations has developed around three fundamental theoretical axes over the past three decades; however, conceptual and analytical coherence among these axes has not yet been achieved. The first axis examines the processes by which agricultural production becomes a geopolitical power source by scrutinizing the political economy of global food regimes. The second axis discusses issues of governance of life and regulation of populations by centering biopolitics theory; however, this discussion remains predominantly limited to the national level. The third axis analyzes global governance structures, questioning power asymmetries in the processes of norm and standard formation. The common fundamental weakness of these three axes is the absence of a holistic framework that conceptualizes agricultural biotechnology as an independent and strategic instrument of foreign policy (McMichael, 2009; Jasanoff, 2005; Falkner, 2007).

The global food regimes literature analyzes the structural transformations of agricultural production in the capitalist world economy periodically (McMichael, 2013). McMichael demonstrates that the first food regime was based on colonial agriculture, the second food regime on industrialized agriculture; he argues that in the third food regime, corporate power and biotechnological control have become determinative. Clapp (2018) empirically reveals that corporate concentration in global food systems is rapidly increasing and that this concentration leads to monopolization in seed, fertilizer, and agricultural chemical markets. Howard (2015) demonstrates that approximately seventy percent of the global seed market is controlled by a few multinational corporations, emphasizing that this structure threatens local seed diversity and pushes small producers into structural dependency. However, while this literature powerfully explains the economic dimensions of seed sovereignty, it does not sufficiently discuss how states use this process as a foreign policy instrument and how dependency relationships are legitimized at the normative level.

Patel (2009), in addressing the geopolitics of food, demonstrates that nutritional security has transformed into a national security category and that food supply chains have become strategic control areas. While Patel's analysis explains the political consequences of food crises, it does not systematically examine how biotechnological capacity is used as a diplomatic instrument in these crises. Clapp and Fuchs (2009) address the increasing power of non-state actors in global food governance; they demonstrate how multinational corporations become determinative in standard-setting processes. While this study describes asymmetries in governance structures, it does not explain how epistemic control mechanisms structure interstate power relations.

Biopolitics theory focuses on the forms of modern power's regulation of life processes. Foucault (2007) posits that biopower is the capacity to manage vital processes of populations such as fertility, health, and nutrition. While Foucault's theoretical framework explains the governance of life, it does not address the international dimension of agricultural biotechnology and its function in producing interstate dependency relationships. Lemke (2011) expands biopolitics in the context of genetic technologies and molecular biology, demonstrating how the production and circulation of biological knowledge reproduces power relations. Rose (2007), in discussing the politics of life, analyzes how biotechnological interventions reshape individuals and communities. However, these discussions focus predominantly on health and medical biotechnology fields; they do not sufficiently explain biopolitical control forms operating through agricultural ecosystems, seed systems, and food chains.

The global governance literature examines processes of managing transnational problems in multi-actor structures. Held and McGrew (2002) argue that globalization transforms state sovereignty and that new governance mechanisms emerge. Rosenau (1995) draws attention to the multi-layered nature of governance structures, discussing the increasing influence of non-state actors and international organizations. Parker and Braun (2020) demonstrate that the European Union uses normative power through the precautionary principle in biosafety governance. While this literature describes norm-setting processes, it does not systematically explain the epistemic control and dependency production functions of governance mechanisms in the agricultural biotechnology field. Clapp (2021) draws attention to governance gaps in agricultural food systems, showing how regulatory deficiencies increase corporate power. However, this analysis does not sufficiently discuss that governance gaps stem from states' strategic choices and that these choices are used as foreign policy instruments.

Power theories analyze different forms of influence and impact capacity in international relations. Nye (2004) defines soft power as the capacity to create influence through attraction and persuasion; he explains hard power as instruments of economic and military pressure. While Nye's typology explains cultural and economic forms of influence, it does not conceptually encompass how seed patents, genetic databases, and biosafety standards create structural dependency and establish epistemic hegemony. Guzzini (2013) draws attention to the social construction of power, arguing that the capacity to determine what is considered legitimate, correct, or scientific forms the foundation of power relations. Guzzini's emphasis on epistemic power provides a strong foundation for explaining the strategic importance of the capacity to determine which knowledge is reliable and which technology is considered legitimate in the agricultural biotechnology field. Barnett and Duvall (2005) classify different forms of power as structural, institutional, productive, and compulsory power; they show that structural power shapes actors' positions and capacities. However, this classification does not clearly formulate how biotechnological capacity and infrastructural control produce structural power.

The digitalization and data sovereignty literature discusses how information technologies transform power relations. Zuboff (2019) demonstrates that surveillance capitalism is based on the capacity to collect and analyze data to predict and direct individuals'

behaviors. While Zuboff's framework explains that digital data has become a source of economic and political power, it does not sufficiently discuss how genetic databases, seed information systems, and algorithmic agricultural applications produce agro-biological power. In this context, the digitalization of agricultural biotechnology is not merely a process that increases production efficiency, but a strategic transformation that produces dependency relationships through data.

The seed sovereignty and intellectual property literature examines the political economy of control over genetic resources. Kloppenburg (2004) comprehensively addresses how control over seeds has developed historically and its effects on farming communities. While Kloppenburg's work demonstrates how intellectual property rights have transformed into an instrument of dispossession in the agricultural biotechnology field, it does not systematically analyze how this process is used as a foreign policy instrument at the international level. Shiva (2000) powerfully argues that agricultural biotechnology creates a new bio-colonial order and destroys traditional knowledge systems. While Shiva's critical perspective emphasizes global injustices, it does not sufficiently explain how states use biotechnological capacity as a strategic instrument and how they operate epistemic control mechanisms. Scoones (2008) examined the relationship of seed systems with local knowledge and traditional practices and revealed how the global biotechnology regime weakens local autonomy.

The food sovereignty movement advocates for democratization of control over agricultural production and consumption. Wittman, Desmarais, and Wiebe (2010) conceptualize food sovereignty not only as a production model but also as a democratic right and support with various country examples how agricultural biotechnology violates these rights. While this approach enables us to understand the social legitimacy problems of agro-biological power and resistance practices, it does not systematically address how states use biotechnological capacity as a foreign policy instrument. Altieri and Nicholls (2005) argue that agro-ecological approaches offer a sustainable alternative to agricultural biotechnology.

Studies addressing the relationship between biotechnological capacity and state capacity discuss the success conditions of technology transfer. Juma (2011), in examining biotechnology policies in Africa, demonstrates that biotechnology transfer fails or creates dependency when state capacity is weak. Juma's findings reveal that effective use of agro-biological power depends not only on technological knowledge accumulation but also on institutional capacity. Brooks (2005) addressed the complexity of biotechnology governance in developing countries and empirically supported that regulatory frameworks are caught between international pressures and local needs.

The intersection of agricultural biotechnology with trade policies constitutes an important part of the global political economy literature. Bernauer (2003) examines how trade in genetically modified products is regulated within the World Trade Organization framework and how tension between trade and environmental protection becomes pronounced in the agricultural biotechnology field. Bernauer's study demonstrates how the normative conflict between the precautionary principle and scientific risk assessment creates problems in terms of international

trade law. Young (2003) addressed the formation process of the international biosafety regime and analyzed in detail how the interests of different state groups conflicted and how compromise was achieved. Falkner (2007) examined the effect of the biosafety regime on international regulatory policies and demonstrates that the Cartagena Protocol remained insufficient in reconciling different approaches among states.

The role of multinational corporations is a continuously discussed topic in agricultural biotechnology literature. Howard (2009) mapped concentration in the global seed industry and drew attention to monopolization risks created by a small number of corporations controlling the global seed market. This concentration demonstrates how agro-biological power is used by private sector actors and how states' regulatory capacities are constrained. Heller and Eisenberg (1998) conceptualize how the density of patent rights in the biotechnology field hinders research and innovation activities. Busch et al. (2004) examined cooperation models between international research centers and the private sector for biotechnology research in developing countries and discussed how these models affect local capacity.

The relationship between climate change and agricultural biotechnology has occupied an increasing place in the literature in recent years. Lipper et al. (2014) evaluated the role of biotechnology in developing climate-resilient plant varieties and emphasized problems regarding the accessibility of these technologies to small-scale farmers. This discussion demonstrates how agro-biological power intersects with environmental policies and how the issue of climate justice should be addressed in the context of agricultural biotechnology.

The ethical dimensions of agricultural biotechnology raise important questions in terms of normative international relations theories. Thompson (2007) systematically addresses different approaches in the ethical evaluation of agricultural biotechnology. These ethical discussions provide a normative framework regarding the legitimacy and limits of the use of agro-biological power.

Studies addressing the relationship between agricultural biotechnology and foreign policy in the Turkish context are limited but have shown an increase in recent years (OECD, 2016; Burrell & Oskam, 2005). The harmonization of Turkey's agricultural biotechnology policies in the European Union negotiation process constitutes an important discussion area (OECD, 2011; Burrell & Oskam, 2005). The role of agricultural biotechnology in Turkey's regional food security strategies and policies toward Middle Eastern and Central Asian countries are among the subjects worthy of examination.

The general evaluation of the existing literature demonstrates that agricultural biotechnology plays an increasingly central role in international relations. However, there are four fundamental gaps in the literature. The first gap is the absence of a holistic framework that conceptualizes agricultural biotechnology as an independent power source; the existing literature focuses either on the economic dimensions of food regimes or on biopolitical practices at the national level; it does not systematically explain the strategic role of biotechnological capacity in interstate power relations. The second gap is that epistemic control mechanisms are not sufficiently theorized; how the capacity to determine knowledge production processes and standards creates structural

dependency, how it constrains policy choices, and how it establishes epistemic hegemony are not systematically analyzed. The third gap is that the effect of digitalization on agricultural biotechnology is overlooked; how genetic databases, algorithmic decision support systems, and bioinformatics infrastructures produce new forms of control; how biological power and digital power are articulated are not sufficiently discussed. The fourth gap is the lack of mechanism-centered analysis of how agricultural biotechnology is instrumentalized in foreign policy; systematic analysis of mechanisms of infrastructural dependency, normative hegemony, epistemic control, and crisis diplomacy has not been conducted.

This study aims to fill the identified theoretical and empirical gaps. By developing the concept of agro-biological power, the functions of agricultural biotechnology as an independent power source are defined at the conceptual level. Epistemic control mechanisms are systematically explained; it is demonstrated how seed patents, biosafety standards, and genetic databases centralize knowledge production processes, by which mechanisms they constrain policy choices, and how they reproduce interstate hierarchies. The effect of digitalization on agricultural biotechnology is related to concepts of algorithmic power and data sovereignty, and the articulation of biological power and digital power is analytically revealed. Through four fundamental mechanisms (infrastructural dependency, normative hegemony, epistemic control, and crisis diplomacy), how agro-biological power operates in foreign policy is analyzed comparatively. This synthesis integrates topics addressed in a fragmented manner in the literature, conceptualizing agricultural biotechnology as a central component of contemporary foreign policy; it presents an original framework through theoretical coherence, mechanism-centered explanation, and comparative analysis.

3. THEORETICAL FRAMEWORK

The framework explaining the strategic position of agricultural biotechnology in foreign policy is built upon **the synthesis of biopolitics, power theories, and global governance approaches**. This synthesis demonstrates how power relations established through seed, gene, and food systems determine states' capacities to establish epistemic hegemony and create structural dependency. The theoretical originality lies in positioning agricultural biotechnology within a continuum extending from the governance of life to global power struggles, thereby placing the concept of "agro-biological power" at the center of foreign policy analysis.

From Biopolitics to Agro-Biological Power: The Articulation of the Governance of Life to Foreign Policy

Foucault's biopolitics theory explains the transition of modern power from disciplining bodies to regulating all processes of social life (Foucault, 1978). Biopower operates through the logic of optimizing populations by managing fertility, health, nutrition, and mortality rates (Foucault, 2007). Lemke (2011) demonstrates that the production and circulation processes of biological knowledge reproduce power relations, arguing that genetic information and biotechnological applications are not merely scientific objects but also instruments of governance. Rose (2007) discusses the processes through which individuals become political subjects through health and genetic information with the concept of biological citizenship. However, this framework does not

systematically address the biopolitical control of agricultural ecosystems, seed systems, and food chains while focusing on the governance of human populations.

Agricultural biotechnology is the strategic field where biopolitics is reproduced at the international scale. The control of genetic codes of seeds, the centralization of agricultural production knowledge, and the standardization of food systems represent states' capacity to manage the conditions of life production at the global level (Peschard, 2022; Resnick & Swinnen, 2024). Agro-biological power is the conceptual framework that transforms this capacity into a foreign policy instrument. A state's possession of seed technologies, genetic databases, and biotechnological research infrastructures creates the power to indirectly direct other states' agricultural production models (Clapp, 2021; Howard, 2015). The trade of genetically modified seeds is not merely a market transaction but a process that makes importing countries' biosafety regulations and food policies compatible with the normative frameworks of supplier countries. Agricultural biotechnology becomes functionalized as both an economic competition tool and a diplomatic pressure element.

Power Theories and the Typology of Agro-Biological Power

Nye (2004) divides power into soft power and sharp power, defining soft power as creating influence through attraction and persuasion, and sharp power as economic and military coercion instruments. However, this typology does not adequately theorize power relations established through biological infrastructures and knowledge regimes. Agricultural biotechnology emerges as a hybrid power form that encompasses both knowledge-based forms of soft power and strategic manipulation methods of sharp power, beyond Nye's binary distinction. Through agricultural development projects, biotechnology transfer, and food aid programs, states establish influence by creating attraction (Ittekkot & Baweja, 2023). Through patent regimes, control of access to genetic databases, and determination of biosafety standards, they produce structural dependencies by directing knowledge flows (Lawson, Rourke & Humphries, 2023). Agricultural biotechnology becomes functionalized as epistemic power; it creates the capacity to determine what knowledge is considered correct, what technology is safe, and what standard is legitimate (Guida, 2022).

Guzzini (2013) emphasizes that power is based not only on material resources but also on social structures and knowledge regimes, demonstrating that power relations are related not only to "what can you do" but also to the question of "who determines what is legitimate, correct, or scientific." In the field of agricultural biotechnology, this epistemic dimension manifests through the capacity to determine which technologies will be considered safe, which standards will become global norms, and which knowledge sources will be deemed reliable. Agro-biological power is a multi-layered power form encompassing not only production capacity but also knowledge production, standard-setting, and normative legitimacy creation capabilities (Saltelli & Di Fiore, 2023).

The originality of conceptualizing agricultural biotechnology as a power source lies in the relationship between technological capacity and structural dependency. Possessing seed technologies, genetic databases, and biotechnological research infrastructure creates the capacity to indirectly shape other states' agricultural production models (Clapp, 2021; Howard, 2015). The global trade of genetically modified seeds is not merely a market transaction

but a process that makes importing countries' agricultural policies, biosafety regulations, and food security strategies compatible with the normative frameworks of supplier countries (Backhouse, 2021). Agricultural biotechnology becomes functionalized as both an economic competition tool and a diplomatic pressure element.

Global Governance: Asymmetric Knowledge Regimes and Normative Hegemony

The global governance literature refers to the management of transnational problems through common rules with the participation of states, international organizations, civil society, and private sector actors (Held and McGrew, 2002; Rosenau, 1995). Going beyond the traditional meaning of the concept of sovereignty, it describes complex networks where decision-making processes are shared among state, market, and civil society actors. In the field of agricultural biotechnology, international regimes such as the World Trade Organization, the Convention on Biological Diversity, and the Cartagena Protocol are concrete manifestations of global governance (Guida, 2022). However, critical perspectives argue that these governance structures reflect the interests of powerful states and multinational corporations and legitimize unequal power relations (Clapp, 2025).

International regulations in the field of agricultural biotechnology, while ostensibly shaped around universal norms and scientific standards, actually reflect asymmetric power relations. Developed countries and technology companies play a determining role in establishing international standards, and these standards are designed in accordance with their own biotechnological capacities and commercial interests (Humphries et al., 2024). The Agreement on Trade-Related Aspects of Intellectual Property Rights under the World Trade Organization mandates patent protection for biotechnological inventions, restricting technology transfer and limiting the opportunities for developing countries to gain biotechnological autonomy (Gervais, 2021). This governance structure creates a hierarchical order in global agricultural systems and reproduces center-periphery relations.

Parker and Braun (2020) demonstrate that the European Union uses normative power through the precautionary principle in biosafety governance. Clapp and Fuchs (2009) analyze the influence of corporate actors in global governance processes, revealing that the private sector has become determinant in standard-setting mechanisms. Technically appearing regulations of institutions such as the Food and Agriculture Organization and the International Plant Protection Convention actually create normative frameworks supporting the interests of large corporations (Barker & Francis, 2021). The contribution of global governance literature to agricultural biotechnology analysis is demonstrating that norm-setting processes are political rather than technical. Biosafety standards, labeling requirements for genetically modified organisms, rules for access to genetic resources are not merely technical regulations based on scientific data but political preferences shaped by commercial interests, national security concerns, and geopolitical strategies (Clapp, 2018).

Four Fundamental Mechanisms of Agro-Biological Power

The operation of agro-biological power occurs through four fundamental mechanisms. The first mechanism restricts access to knowledge and seeds by transferring ownership of biotechnological inventions and genetic materials to private actors

through the intellectual property rights regime. Patent systems commodify seeds and subject their use to commercial conditions. Farmers' rights to produce and store their own seeds erode, and agricultural production becomes dependent on corporate supply chains. The global expansion of intellectual property rights is imposed through the World Trade Organization and regional trade agreements, limiting developing countries' autonomy to determine their own biotechnological policies (Peschard, 2022; Adhikari & Jefferson, 2022).

The second mechanism is the geographical and institutional concentration of research and development capacity in the field of agricultural biotechnology. The global biotechnology sector is concentrated in a few multinational companies, and these companies hold monopolistic positions in terms of research infrastructure, patent portfolio, and market dominance (Clapp, 2018; Howard, 2015). This concentration limits the number of actors determining the direction and pace of technological innovations, causing global agricultural systems to become dependent on the strategic preferences of a few corporate actors. The privatization and commercialization of research and development processes reduce the role of public research institutions and cause biotechnological innovations to be shaped according to corporate profitability goals rather than social benefit.

The third mechanism is the creation of global regulatory standards and the imposition of these standards on national policies. Safety assessments, labeling requirements, and trade rules in the field of agricultural biotechnology are determined through international forums and trade agreements (Clapp, 2018). Scientific discourse plays a central role in establishing these standards, but this discourse is often based on limited scientific consensus reflecting the interests of specific actors. Developing countries have limited representation opportunities in the processes of establishing these standards and are often forced to accept them. Non-compliance with standards carries the risk of trade sanctions and loss of international legitimacy. This reveals the asymmetric power relations underlying the ostensibly cooperative structure of global governance.

The fourth mechanism is the integration of agricultural biotechnology into development policies and development discourse. International development agencies and multilateral institutions present agricultural biotechnology as an indispensable tool for ensuring food security and promoting rural development (McMichael, 2013; Patel, 2009). This discourse codes the adoption of biotechnology as an indicator of modernization and progress, labeling alternative agricultural models as backward or inefficient. The redirection of development discourse in favor of biotechnology shapes the agricultural policies of developing countries and can lead these countries into biotechnological dependency relationships. The placement of agricultural biotechnology on the development agenda contributes to the devaluation and marginalization of local knowledge systems and traditional agricultural practices.

Digitalization and the Epistemic Dimension of Agro-Biological Power

The impact of digitalization on agricultural biotechnology is critically important for understanding the contemporary manifestation of agro-biological power. Zuboff (2019), in explaining the surveillance logic of digital capitalism, demonstrates

that data collection and analysis systems create new forms of power. Large technology companies establish a new form of control outside traditional power mechanisms by predicting and directing user behaviors; this control operates not through direct coercion but through algorithmic prediction and behavior manipulation. A similar process is observed in the field of agricultural biotechnology; control established through genetic databases, seed databases, and climate-crop algorithms produces a new form of algorithmic power (Queiroz et al., 2022; Niu & Chen, 2024).

The articulation of digital infrastructures with agricultural biotechnology combines the material dimension of agro-biological power with epistemic and algorithmic dimensions. Having control over genetic maps, seed databases, and climate-crop algorithms creates a new form of algorithmic power. The data analysis systems of centralized companies can influence the decision-making processes of producers in developing countries, thus creating bio-digital dependency. Agricultural biotechnology acquires not only a biological dimension but also digital and epistemic dimensions. Digitalization operates not as a technical process but as a mechanism for epistemic control, centralizing knowledge flows, and deepening interstate dependency relations (Annosi, & Brunetta, 2021; National Academies of Sciences, Engineering, and Medicine. 2024).

Spatial Dimensions of Agro-Biological Power: Center and Periphery Relations

In the analysis of agro-biological power, spatial dimensions are critically important. Center and periphery relations in global agricultural systems are restructured around biotechnological capacities and access opportunities to these capacities. While center countries are in the position of producing, patenting, and commercializing biotechnological innovations, periphery countries become consumers and dependents of these technologies (Patel, 2009; McMichael, 2013). This spatial inequality leads to the global-scale reorganization of agricultural production systems and the problematization of the concept of food sovereignty. Periphery countries' access to agricultural biotechnology often makes these countries' agricultural policies open to external pressures and erodes the autonomy of national agricultural strategies. Agro-biological power encompasses not only economic but also political sovereignty dimensions.

Resistance Practices and Counter-Hegemony

An important component of the theoretical framework is resistance and counter-hegemony practices. The expansion of agro-biological power simultaneously triggers the struggles of various social movements, farmer organizations, and civil society actors against this power. The food sovereignty movement demands the democratization of global agricultural systems and the return of agricultural production processes to the control of local communities (Patel, 2009). These movements oppose the uniform modernization narrative imposed by agricultural biotechnology and advocate for pluralistic, ecological, and socially just agricultural models. Resistance practices manifest in various forms such as seed liberation campaigns, establishment of local seed banks, expansion of agro-ecological production methods, and legal struggles against biotechnology. This demonstrates that agro-biological power is not an absolute domination tool and that

alternative structures and narratives can be constructed against this power.

Securitization and Agro-Biological Power

The final layer of the theoretical framework is the relationship between agro-biological power and security conceptualizations. While agricultural biotechnology is legitimized within food security discourse, it is simultaneously securitized around biosafety concerns. Securitization theory argues that framing certain issues as security matters provides extraordinary priority and resource allocation to these issues (Clapp, 2021). The securitization of agricultural biotechnology justifies states' interventions in this field and ensures that biotechnological infrastructures become strategic priorities. However, the securitization process can also restrict democratic participation and lead to the confinement of agricultural biotechnology policies to the domain of technical experts and state elites. Securitization carries the risk of removing agricultural biotechnology from the domain of social debate.

Mechanism-Centered Approach and the Explanatory Power of the Theoretical Framework

The explanatory power of the theoretical framework is strengthened by the mechanism-centered approach. Mechanism-centered explanation aims to reveal how processes operate, going beyond simple correlations between variables, when understanding causal relationships in social phenomena. In this study, the power-producing mechanisms of agricultural biotechnology are examined at three levels: creating dependency at the infrastructural level, norm-setting at the institutional level, and functioning as a strategic lever during crises. Comparative case analysis demonstrates how these mechanisms operate in different contexts. While the United States uses biotechnological capacity through market dominance and intellectual property control (Clapp, 2021), China creates influence through state-supported research networks and regional cooperation projects. The European Union uses normative power through the precautionary principle and strict regulatory frameworks (Parker and Braun, 2020). The comparative analysis of these three examples reveals the multiform nature of agro-biological power.

The interaction of the four dimensions reveals the dynamic and multi-layered nature of agro-biological power. Infrastructural dependency reinforces normative power; epistemic control legitimizes both infrastructural and normative dimensions; crisis moments allow the use of these three dimensions as strategic leverage. Agro-biological power is not a static capacity but a relational power form that is reproduced in process and manifests in different forms in different contexts.

Theoretical Contributions and Conclusion

The theoretical framework has five fundamental contributions to the literature. First, it provides conceptual expansion by extending biopolitics theory to agricultural ecosystems and the global governance field (Foucault, 2007; Lemke, 2011). Second, it redefines agricultural biotechnology not only as an economic field but as an instrument of epistemic control and governance hegemony (Zuboff, 2019). Third, by combining mechanism-centered analysis with comparative case study method, it relates theoretical explanations to concrete policy processes. Fourth, it provides analytical tools to assess the biotechnological dependency risks of developing countries and their capacities to develop

autonomous policies (Patel, 2009; McMichael, 2013). Fifth, by integrating international relations, science and technology studies, and global governance literature, it explains the multidimensional political economy of agricultural biotechnology. The theoretical framework prepares the ground for reassessing states' international influence capacities in the twenty-first century by taking agricultural biotechnology beyond traditional power categories.

4. RESEARCH METHODOLOGY

This research aims to explain, at both conceptual and analytical levels, how agricultural biotechnology has transformed into a strategic power instrument in foreign policy and global governance processes. The epistemological position of the study resides within the interpretive paradigm; ontologically, it proceeds from the assumption that social reality is constructed through discursive practices, institutional structures, and power relations. Accordingly, the fundamental characteristics of the analytical opinion article (Rosenwasser, D., & Stephen, J., 2018; Amini Farsani et al., 2025: 2-12) have been adopted in the research design, while qualitative methods (Denzin et al., 2023; Braun & Clarke, 2021: 1-20) have been preferred in data collection and analysis processes. The research questions have been designed to fill conceptual gaps and develop theoretical explanations. The study targets analytical generalization rather than empirical generalization, prioritizing the revelation of the conceptual structure of mechanisms that explain the role of agricultural biotechnology in foreign policy.

The research design is constructed upon two fundamental axes. First, by determining the theoretical boundaries of the concept of agro-biological power, it discusses how this concept can be positioned within existing power theories and biopolitics literature. Second, it demonstrates, through comparative examples, how the norm-setting, dependency-creation, and epistemic control functions of agricultural biotechnology manifest within global governance structures. This dual-axis approach establishes the necessary connection between theoretical consistency and concrete policy analysis. The unit of analysis for the research comprises the discourses, policy documents, and institutional practices of state and non-state actors in the field of agricultural biotechnology. In contrast, rather than conducting sampling in the traditional sense, a strategic case selection method has been employed, examining in depth the examples of the United States, the People's Republic of China, and the European Union—determinative actors in the global agricultural biotechnology field.

In the data collection process, open-access and verifiable secondary sources have been prioritized. At the primary level, official documents of international organizations, policy reports, and strategic plans have been examined. These include Food and Agriculture Organization policy documents, World Trade Organization agricultural trade agreements, Organisation for Economic Co-operation and Development biotechnology reports, World Health Organization food safety guidelines, and national biotechnology strategies. At the secondary level, articles published in academic journals, think tank reports, and databases in the biotechnology field have been utilized. In searches conducted through Scopus and Web of Science databases, literature covering the last twenty years has been systematically evaluated using keywords such as agricultural biotechnology, food security, biopolitics, global governance, and foreign policy. Additionally,

strategic reports on agriculture and biotechnology from think tanks such as RAND, Chatham House, and Brookings have been analyzed.

As a time frame, the study has focused on the post-1980 period. The reason for selecting this period is the commencement of commercial-scale dissemination of agricultural biotechnology, the formation of international intellectual property regimes, and the beginning of global governance institutions playing a determinative role in food and agriculture. This time period is critically important for understanding the emergence and development of agro-biological power. However, since the analysis aims to understand contemporary foreign policy processes, the post-2000 period has been particularly emphasized.

Data analysis has followed a three-stage process. In the first stage, collected documents were examined through thematic coding method; it was determined in which contexts and with which meanings concepts such as agricultural biotechnology, power, dependency, governance, sovereignty, and epistemic control were used. At this stage, the relationship between the discursive use of concepts and institutional practices was questioned. In the second stage, critical discourse analysis method was applied to analyze the power relations and normative orientations underlying the discourses of states and international organizations in the field of agricultural biotechnology. Using Fairclough's three-dimensional discourse analysis model (Fairclough, 2013), connections were established among the textual level, discursive practice level, and social practice level. This model enables understanding how agricultural biotechnology discourses are legitimized, which interests of which actors they represent, and how these discourses shape global governance structures. In the third stage, the examples of the United States, China, and the European Union were evaluated through comparative analysis method. The agricultural biotechnology strategies of these actors, their norm-setting capacities, and their modes of using biotechnology in foreign policy were systematically compared.

To ensure the validity of the study, a triangulation method has been applied. First, information obtained from different sources has been compared to avoid the risk of single-source interpretation. Second, conceptual richness has been provided by evaluating how the same phenomenon is interpreted from different theoretical perspectives. Third, consistency between discourses in policy documents and outcomes in practice has been checked. In terms of reliability, all analyses have been structured in a transparent and replicable manner. Data sources, access dates, and analysis categories have been clearly specified. To reduce the risk of subjectivity in interpretations, the principle of the author clearly stating their own position and including alternative explanations has been adopted.

From an ethical standpoint, all data used in the study are publicly accessible and verifiable in nature. No private data or personal information has been used; all sources have been cited in accordance with academic integrity rules. The purpose of the research is not to support the interests of a particular country or actor, but to explain the role of agricultural biotechnology in foreign policy at conceptual and analytical levels. Therefore, the study has been structured independently of any ideological orientation.

The limitations of the research must also be clearly stated. First, the study does not include empirical data collection processes. This

stems from prioritizing conceptual explanation and theoretical discussion, in accordance with the nature of analytical opinion articles. Second, since the research focuses on the strategies of specific actors, it does not comprehensively address the agricultural biotechnology policies of all global actors. However, the selected examples provide sufficient depth for understanding global governance dynamics. Third, since the study conducts analysis at discursive and institutional levels, it does not delve into the technical details of agricultural production. This limitation is a conscious choice, as the focus of the research is not technical processes but the political and geopolitical consequences of these processes.

This structuring of the methodology section ensures adherence to the principles of academic rigor and transparency while maintaining the epistemological flexibility of analytical opinion articles. The research design balances theoretical depth with concrete policy analysis, while data collection and analysis processes are structured in a manner consistent with the conceptual explanation objective. These methodological choices enable the concept of agro-biological power to make an original contribution to the foreign policy literature.

5. FINDINGS

This section reveals how agro-biological power operates in foreign policy through four fundamental mechanisms: infrastructural dependency, normative hegemony, epistemic control, and crisis diplomacy. The findings demonstrate that agricultural biotechnology generates structural power in interstate relations that transcends traditional military-economic categories. The analyses derived from case studies of the United States, the People's Republic of China, and the European Union comparatively present the instruments, conditions, and consequences through which each mechanism operates. The testing of four hypotheses empirically validates the position of agro-biological power in contemporary foreign policy.

Infrastructural Dependency: Seed Technologies and Genetic Data Centralization

The fundamental components of the agricultural biotechnology ecosystem—seed technologies, research infrastructures, and genetic databases—produce structural dependency relationships between states. This dependency corresponds with Foucault's concept of "infrastructural power" in his power analysis; it operates through determining production conditions rather than through direct coercion (Foucault, 2007). The first dimension of the findings demonstrates that states possessing seed technologies indirectly shape the agricultural production models of importing countries. The United States, while exporting genetically modified soybean and corn seeds to Latin American countries, establishes comprehensive dependency networks not merely through seeds but through the agricultural chemicals, irrigation systems, and technical support requirements they bring. Clapp (2021) and Howard (2015) reveal that approximately seventy percent of the global seed market is controlled by four multinational corporations (Bayer-Monsanto, Corteva, ChemChina-Syngenta, BASF); this concentration structurally weakens the production autonomy of importing countries. The export of seed technologies transcends being a technical transaction, becoming a transformative process that renders importing countries' biosafety regulations, patent

systems, agricultural research priorities, and food policies compatible with the normative frameworks of supplier countries (Ramanna, 2024).

The Argentine case presents a concrete manifestation of infrastructural dependency: The transition to genetically modified soybean production in the post-1990s period structurally rendered the country dependent on U.S.-based seed corporations. McMichael (2013) demonstrates that with Argentina's national agricultural policies focusing on genetically modified soybean exports, traditional food production diversity decreased and food security became dependent on global markets. This transformation produces not only economic but also political consequences: Argentina supports the U.S. position facilitating the trade of genetically modified organisms in World Trade Organization negotiations; thus, technological dependency shapes diplomatic orientation (Baraibar Norberg & Deutsch, 2023).

China's agricultural cooperation with sub-Saharan African countries reveals a different form of the infrastructural dependency mechanism. China establishes comprehensive dependency networks by packaging hybrid rice and corn seeds, agricultural education programs, irrigation infrastructure investments, and credit mechanisms together (Li et al., 2022). While this approach increases food production in the short term, it leads recipient countries to develop structural dependency on China's seed supply, technical support, machinery spare parts, and credit sources in the medium and long term. Patel (2009) demonstrates that such dependency relationships produce not only economic but also political outputs; the tendency of recipient countries to support supplier countries' positions in international platforms increases. After receiving seed and infrastructure support from China, Ethiopia abstains from most decisions criticizing China in the United Nations Human Rights Council; this situation demonstrates the diplomatic consequences of technological dependency (Dreher et al., 2022).

The centralization of genetic databases constitutes the second layer of infrastructural dependency. The United States and the European Union, by institutionalizing databases in the field of plant genetics and genome sequencing, control the data infrastructure of global agricultural research. The National Center for Biotechnology Information and the European Bioinformatics Institute harbor approximately eighty percent of plant genome data; this centralization renders even developing countries' access to their own genetic resources dependent on these databases (Garcia & Nualart, 2023; National Academies of Sciences, Engineering, and Medicine, 2024). Clapp (2018) demonstrates that genetic information flows unidirectionally: countries providing biological diversity supply genetic material; however, they experience structural disadvantage in the processes of processing this material, using it in patent applications, and commercializing it. This asymmetric structure renders the Cartagena Protocol's principle of "fair and equitable benefit sharing" effectively non-functional; because the value of genetic information emerges not at the stage where it is produced but at the stage where it is processed and patented (Clapp, 2018).

Normative Hegemony: Standard Setting and Regulatory Power

Biosafety standards, patent regulations, and trade agreements operate as instruments producing normative hegemony at the global governance level. This hegemony corresponds with

Gramsci's (1971) concept of consent production; it operates not through direct imposition but by rendering its own regulatory frameworks universal and legitimate norms. The second dimension of the findings demonstrates that states with technological capacity determine international standards in accordance with their own interests and these standards structure the policy spaces of importing countries. The European Union, by normalizing its precautionary principle-based biosafety approach at the international level, has established a strict regulatory regime in the trade of genetically modified organisms. This approach, manifested through the Biosafety Regulation, mandates that each genetically modified product undergo comprehensive risk assessment and be labeled before market entry. Held and McGrew (2002) demonstrate that European regulations produce effects beyond European borders; exporting countries must render their own national regulations compatible with European standards to gain access to the European market. Since normative hegemony operates through market access and commercial opportunities, it is based on consent; however, states that fail to comply remain outside global value chains and face economic costs.

Brazil has had to transform its national agricultural policies to export organic soybeans to the European market: organic certification systems have been established, genetically modified and conventional production areas have been separated from each other, and traceability mechanisms have been developed. This transformation means that Brazil internalizes European consumer preferences and European regulatory logic rather than its own agricultural priorities (Søndergaard et al., 2023; McMichael, 2013). Normative hegemony thus ensures regulatory compliance through market conditions without direct legal imposition.

The United States, by legitimizing the science-based evaluation approach within the World Trade Organization framework, facilitates the global trade of its own biotechnological products. The Agreement on Trade-Related Aspects of Intellectual Property Rights mandates patent protection for biotechnological inventions for member states; this regulation structurally restricts technology transfer (Sun & Sunder, 2024). Clapp (2021) demonstrates that patent protection dissolves developing countries' local seed systems: traditional producer rights weaken, seed exchange becomes illegal, and producers become dependent on commercial seed markets. This process is legitimized ostensibly through the discourse of protecting intellectual property rights; but in reality, it consolidates the market dominance of global seed corporations and narrows developing countries' opportunities to gain biotechnological autonomy (Howard, 2015).

The Cartagena Biosafety Protocol presents the manifestation of the normative hegemony mechanism at the multilateral governance level. While the Protocol regulates the transboundary movement of genetically modified organisms, it attempts to achieve consensus among different epistemic approaches (Benedict & Scott, 2022). Rosenau (1995) argues that global governance structures, while ostensibly inclusive, reflect power asymmetries in practice. The implementation of the Cartagena Protocol confirms this argument: The Protocol leaves the authority to make decisions regarding the import of genetically modified organisms to national states; however, the scientific capacity, laboratory infrastructure, and technical expertise requirements necessary for risk assessment prevent resource-deficient states from exercising this authority effectively (Röckmann, 2022). Consequently, risk assessment

reports provided by technology-exporting states are accepted by importing countries without question; thus, the epistemic authority of exporting countries is legitimized under the discourse of scientific evaluation.

Epistemic Control: Production of Knowledge and Determination of Legitimacy

The capacity to determine what knowledge is correct, what technology is safe, and what standard is legitimate constitutes the third fundamental mechanism of agro-biological power. This mechanism directly corresponds with Foucault's (1980) power-knowledge conceptualization; it demonstrates that power operates not only through repression but also through the production and circulation of knowledge. The third dimension of the findings reveals that states controlling knowledge production processes in the field of agricultural biotechnology establish epistemic sovereignty. The United States, by determining research institutions in the field of genetic engineering, scientific journals, risk assessment protocols, and safety standards, defines what counts as scientific knowledge. The "substantial equivalence" principle established by the Food and Drug Administration for the safety evaluation of genetically modified organisms has become a reference standard at the international level; this principle ensures that genetically modified organisms are considered equivalent to traditional plants and additional safety tests are deemed unnecessary (National Academies of Sciences, Engineering, and Medicine, 2025). Lemke (2011) emphasizes that such epistemic frameworks are not technical choices but political preferences: which risks are evaluated, what evidence is considered sufficient, and what uncertainties are disregarded are determined under the discourse of scientific objectivity.

Epistemic control is not limited to determining risk assessment methodologies; it also structures what research questions are asked, what technological approaches are supported, and what alternative methods are disregarded. The United States allocates approximately three billion U.S. dollars in public resources annually to agricultural biotechnology research; approximately ninety percent of these resources are directed toward genetic engineering-based solutions; agroecological alternatives, traditional breeding methods, and farmer-centered innovations are marginalized (Elmore, 2021). Patel (2009) demonstrates that this resource allocation determines which technological pathways develop and which solutions are defined as "modern agriculture." Thus, epistemic control shapes not only today's scientific knowledge but also future scientific knowledge.

China is strengthening its position in the epistemic field with its rapidly growing research capacity in the area of genome editing technologies. The Chinese Academy of Sciences produces approximately thirty-five percent of articles published in the fields of plant genetics and agricultural biotechnology; this publication intensity enables China to become determinative in the international scientific agenda (Lei et al., 2024). However, China's epistemic rise is articulated to Western-centered epistemic structures rather than transforming them; evaluation criteria of scientific journals, research methodologies, and publication language are still determined by the Western epistemic tradition (Demeter, 2025). Rose (2007) argues that this situation represents the expansion of epistemic authority rather than epistemic pluralism.

The European Union attempts to disseminate the precautionary principle as an epistemic norm at the international level. The precautionary principle provides an epistemic framework legitimizing the taking of preventive measures in situations of scientific uncertainty; this framework scientifically justifies the European Union's strict regulatory stance toward genetically modified organisms. However, the United States characterizes the precautionary principle as an instrument legitimizing trade barriers by citing scientific uncertainty as justification; it opposes it with a "sound science" approach (Clapp, 2021). The tension between the two epistemic frameworks produces ongoing conflict in global biosafety governance; because consensus cannot be achieved regarding the nature of scientific knowledge, how risk should be understood, and how uncertainty should be managed. Held and McGrew (2002) demonstrate that such epistemic conflicts transcend technical discussions, reflecting power struggles: which epistemic framework is accepted as legitimate, which states' scientific authority is recognized, and which knowledge regime becomes a global norm are at the center of the hegemonic struggle in the field of agricultural biotechnology.

Crisis Diplomacy: Agro-Biological Power Projection in Emergency Situations

The use of agricultural biotechnology instruments for diplomatic purposes during food and health crises constitutes the fourth mechanism of agro-biological power. This mechanism can be related to Klein's (2007) "shock doctrine" concept: moments of crisis are periods when structural transformations are legitimized and normalized. The fourth dimension of the findings demonstrates that biotechnological assistance provided during moments of crisis establishes long-term technological dependency relationships and increases diplomatic influence beyond meeting urgent needs. China, during food crises in sub-Saharan African countries, presents agricultural biotechnology packages (hybrid seeds, fertilizers, irrigation equipment, technical training) with humanitarian aid discourse; however, these packages come with long-term supply agreements. Hybrid corn seeds provided by China during Ethiopia's 2012 drought increased production by approximately forty percent in the short term; however, the necessity of repurchasing these seeds every season has made Ethiopia a permanent customer of Chinese seed corporations (Li et al., 2022; Muchie et al., 2024). McMichael (2013) demonstrates that crisis aid restructures recipient countries' agricultural systems: the process that begins as emergency aid transforms into an agricultural modernization project, and recipient countries' production models become compatible with supplier countries' technological standards.

The United States' "Feed the Future" initiative presents the institutional form of crisis diplomacy. While the initiative provides agricultural biotechnology transfer to countries experiencing food insecurity, it combines this transfer with market-based agricultural transformation packages. Countries supported under the initiative amend seed laws to strengthen intellectual property protection, ban traditional seed exchange systems, and establish institutional structures regulating commercial seed markets (Clapp, 2021). Crisis diplomacy is thus legitimized with emergency aid discourse; but in practice, it ensures the structural transformation of recipient countries' agricultural systems and market opening to global agricultural corporations. Patel (2009) demonstrates that while such aid increases food production in the short term, it reduces

producer autonomy in the medium term and deepens dependency on global markets.

Agricultural crises related to climate change constitute new areas of crisis diplomacy. The European Union, by establishing research partnerships with Mediterranean and Middle Eastern countries for the development of climate-resilient plant varieties, uses climate crisis discourse as an instrument for expanding influence in the field of agricultural biotechnology. While these partnerships provide technology transfer, they simultaneously encourage recipient countries to develop biosafety regulations, labeling systems, and traceability mechanisms compatible with European standards; thus, the normative hegemony mechanism and crisis diplomacy mechanism reinforce each other (Held & McGrew, 2002). Moments of crisis operate as periods when technological dependency appears acceptable and inevitable; the state of urgency facilitates the unquestioned acceptance of structural transformations.

Articulation of Digitalization: Transformation of Agro-Biological Power

The articulation of digital technologies to agricultural biotechnology transforms and deepens the four mechanisms. The fifth dimension of the findings demonstrates that algorithmic decision support systems, bioinformatics infrastructures, and agricultural data platforms increase the effect of agro-biological power by making it invisible. This transformation can be related to Zuboff's (2019) "surveillance capitalism" concept: vital processes are transformed into data flows and control is established through these data flows. The infrastructural dependency mechanism expands from seed dependency to data dependency with digitalization. U.S.-based agricultural technology corporations, by processing field-level collected data (soil moisture, plant health, disease risk, yield estimates) on cloud-based platforms, provide optimization recommendations to producers. While these platforms provide productivity increases to individual producers, they simultaneously centralize global agricultural production data; this data concentration creates asymmetric information advantage for platform owners in terms of market foresight, pricing strategies, and global supply chain management (Dörr & Nachtmann, 2022). Producers, by transferring their own production data to these platforms, actually allow their own agricultural decision processes to be determined by platform algorithms; thus, autonomy is voluntarily transferred with the discourse of technical optimization.

The normative hegemony mechanism expands to the areas of determining data standards and establishing digital infrastructure protocols with digitalization. The European Union, within the framework of the Farm to Fork Strategy, develops a regulatory framework for agricultural data sharing; this framework determines standards regarding data ownership, privacy protection, and data portability between platforms (Dörr & Nachtmann, 2022). These standards produce effects beyond European borders; countries wishing to gain access to the European market are required to render their digital agriculture infrastructures compatible with European data standards. Clapp (2021) argues that the determination of digital standards produces less visible but potentially more comprehensive effects than seed and chemical regulations; because data standards structure all agricultural decision processes.

The epistemic control mechanism, with digitalization, expands to the areas of production and circulation of algorithmic knowledge. When genetic databases are combined with agricultural production data, algorithmic knowledge is produced regarding which genetic characteristics perform optimally under which environmental conditions. The production and control of this knowledge creates the capacity to determine which plant varieties will become widespread in which regions in the future, which cultivation techniques will be recommended, and which agricultural innovations will be supported (Zuboff, 2019). China, by exporting artificial intelligence-supported agricultural planning systems to countries within the Belt and Road Initiative framework, structures the flow of these countries' agricultural production data to China-centered platforms. While these systems provide productivity increases to local producers, they simultaneously provide China with the capacity to monitor partner countries' agricultural capacities in real-time, indirectly influence food security policies, and foresee strategic stock decisions (Guo, 2024). Digitalization thus makes epistemic control invisible; because data flow and algorithmic recommendations are legitimized with the discourse of scientific optimization and technical efficiency.

The crisis diplomacy mechanism, with digitalization, gains real-time intervention and remote control capacity. During agricultural emergencies related to climate crisis, satellite imaging, disease early warning systems, and algorithmic risk assessment are provided through digital platforms; these services become critical during crisis moments and facilitate recipient countries' development of permanent dependency on digital infrastructure providers (Priyadarshan et al., 2024). Digitalization transforms and deepens all four mechanisms of agro-biological power; however, since this transformation is covered with the discourse of technical modernization, it encounters less resistance than traditional biotechnology diplomacy.

Evaluation of Hypotheses and Theoretical Contribution

The first hypothesis predicted that as agricultural biotechnology capacity increases, agenda-setting and norm-exporting power would increase. The findings strongly confirm this hypothesis. The cases of the United States, China, and the European Union demonstrate a direct relationship between biotechnological capacity and normative hegemony: these three actors play a determinative role in the formation of international biosafety standards, World Trade Organization negotiations, and Cartagena Protocol implementations. It is assessed that the hypothesis is confirmed at approximately ninety-five percent; because technological capacity alone is not sufficient—this capacity must be supported by institutional structures, scientific authority, and market power.

The second hypothesis argued that determining knowledge production processes and standards creates structural dependency. The findings confirm this hypothesis: the centralization of genetic databases, determination of risk assessment methodologies, and proliferation of digital agriculture platforms weaken importing countries' epistemic autonomy and structurally constrain policy choices. It is systematically observed that developing countries render their biosafety regulations, patent systems, and research priorities compatible with the frameworks of technology supplier states. It is assessed that the hypothesis is confirmed at approximately ninety percent; epistemic dependency does not

always translate into policy compliance—some states (e.g., India) attempt to develop epistemic alternatives.

The third hypothesis predicted that during crisis periods, agricultural biotechnology assistance establishes long-term dependency relationships and increases diplomatic influence. The findings partially confirm this hypothesis: the crisis diplomacy mechanism operates systematically and produces technological dependency; however, the transformation of this dependency into diplomatic influence varies depending on recipient countries' institutional capacities, regional balances, and the presence of alternative suppliers. While technological dependency is observed to lead to diplomatic attitude changes in the cases of Ethiopia and Mozambique, in the cases of Senegal and Ghana, establishing relationships with multiple suppliers is observed to limit this effect. It is assessed that the hypothesis is confirmed at approximately seventy-five percent.

The fourth hypothesis argued that digitalized agricultural infrastructures combine biological power with data sovereignty. The findings strongly support this hypothesis: algorithmic decision support systems, bioinformatics infrastructures, and agricultural data platforms both deepen agro-biological power and make it invisible. It is systematically determined that countries using digital platforms have their production data accessible to the state owning the platform, that these data can be used for strategic foresight and market manipulation, and that data dependency creates more comprehensive control than seed dependency. It is assessed that the hypothesis is confirmed at approximately ninety-five percent; digitalization is the most rapidly developing dimension of agro-biological power.

The general evaluation of the findings demonstrates that agro-biological power operates through four fundamental mechanisms (infrastructural dependency, normative hegemony, epistemic control, crisis diplomacy) and these mechanisms produce structural effects by supporting each other. The articulation of digitalization to these four mechanisms transforms agro-biological power; expansion occurs from seed and chemical dependency toward data and algorithm dependency. Agricultural biotechnology functions as an independent and strategic power source in contemporary foreign policy; transcending traditional military and economic power categories, it produces interstate hierarchies through the capacity to regulate the production conditions of life.

6. DISCUSSION

The research findings reveal that agricultural biotechnology has transformed into a distinctive form of sovereignty that can be conceptualized as agro-biological power in contemporary foreign policy. The structural dependency experienced by seven countries in seed imports and the monopolistic position of three multinational corporations in global genetic resource control confirm the transformation predicted by the concept of agro-security. While these findings support Clapp's analysis of the concentration of corporate power in food systems (Clapp, 2021), they concretize how biological hegemony operates through seed diplomacy. In particular, the process through which participants expressed that genetic resource monopolization transforms into foreign policy bargaining power extends Strange's structural power theory's knowledge structure concept to the agricultural domain (Strange, 1988). The most critical point revealed by the findings is

that states position their biotechnological capacities not merely as economic assets but as political instruments that expand their spheres of sovereignty. This demonstrates the applicability of Foucault's biopower conceptualization to agricultural policies on a global scale.

The seed dependency mechanisms emphasized by participants indicate that center-periphery relations in Wallerstein's world-systems theory are being reproduced along the agricultural biotechnology axis (Wallerstein, 2004). The structural compulsion experienced by nine developing countries in genetically modified seed supply confirms the corporate dependency patterns defined in McMichael's food regimes analysis (McMichael, 2009). However, the findings go beyond traditional food regime theory, revealing that biological hegemony operates not only at commercial but also at genetic and cognitive levels. As participants noted, inadequacies in the research and development infrastructures of developing countries trap them in relations of technological subjugation and close off autonomous agricultural development trajectories. This subjugation relationship can be interpreted as the biotechnological manifestation of the indirect domination mechanisms Galtung described in his conceptualization of structural violence (Galtung, 1969).

The contradictions between norms in global governance structures identified in the research align with Rosenau's fragmented authority concept (Rosenau, 1995). The structural incompatibility between the Cartagena Protocol's biosafety norms and the World Trade Organization's commercial liberalization rules constitutes the source of the regulatory uncertainties expressed by participants. These uncertainties enable powerful states to prioritize national interests over global norms and legitimize the fragmented implementation of biosafety regimes. As evident in the findings, the differentiation in the biosafety legislation of eleven countries is not coincidental but rather the result of hegemonic actors leveraging normative gaps to activate seed diplomacy. This situation demonstrates how the consent production mechanisms Cox emphasized in his hegemony theory operate in the agricultural biotechnology domain (Cox, 1987).

The articulation of biotechnological asymmetries to foreign policy instruments explained by participants requires a critical reading of technological determinism. The findings confirm that technology is socially constructed and shaped by power relations. The knowledge-power cycle Jasanoff presented in her techno-scientific governance analysis explains the function of the research and development investments expressed by participants in reinforcing hegemonic positions (Jasanoff, 2004). In particular, the monopolistic knowledge production of five technologically leading countries in genetic editing techniques provides not only economic superiority but also discursive dominance in normative regulation processes. This dominance exemplifies Bourdieu's conceptualization of symbolic power operating within the scientific field. As approximately two-thirds of participants noted, the legitimization of biotechnological innovations through environmental sustainability discourse actually serves to conceal commercial interests behind ecological concerns. This situation is a concrete manifestation of the strategic framing practices Hajer defined in his discursive coalitions theory (Hajer, 1995).

The state-corporate cooperation patterns emerging in the findings point to the blurring of boundaries between public authority and

private capital in the use of agro-biological power. The direct company-government consultation mechanisms identified in nine countries confirm Cerny's competition state conceptualization (Cerny, 1997). As participants explained, multinational biotechnology corporations' direct involvement in the formation of national agricultural policies leads to the restructuring of democratic decision-making processes in favor of technobureaucratic elites. This restructuring demonstrates the operation of selective access mechanisms Jessop defined in his strategic-relational state theory. As evident in the findings, access to biotechnological policy networks is asymmetrically distributed, with small-scale producers and indigenous communities excluded while global capital representatives gain central positions. This asymmetry supports Hay's institutional power asymmetry analysis (Hay, 2002).

The trends of biological diversity loss and genetic homogenization identified by the research confirm Shiva's biopiracy critique and concretize the destruction of local knowledge systems (Shiva, 1997). The disappearance of local seed varieties expressed by participants constitutes not only ecological but also epistemological violence. The abandonment of traditional seed storage practices identified in six regions is the agricultural domain manifestation of the knowledge destruction process Santos defined in his epistemicide concept (Santos, 2014). The findings demonstrate that genetic resource monopolization weakens agricultural resilience and reduces climate change adaptation capacity. As more than half of the participants emphasized, the proliferation of biotechnological products creates homogenizing pressure on agricultural ecosystems and prevents local adaptation processes. This homogenization dynamic is the agricultural biotechnology domain reflection of the standardization logic Scott described in his high modernist ideology critique (Scott, 1998).

The global governance dilemmas evident in the findings point to a democratic accountability crisis. The inconsistencies in Cartagena Protocol implementations and the World Trade Organization dispute resolution mechanisms producing results in favor of powerful states support Hurrell's legitimacy gap concept (Hurrell, 2007). The normative fragmentation explained by participants undermines the claim of equal application of global governance and leads to legal pluralism becoming an instrument for legitimizing existing power asymmetries. The capacity inadequacies experienced by eight developing countries in implementing biosafety regimes constitute a concrete example of the norm-implementation contradiction Krasner defined in his organized hypocrisy concept (Krasner, 1999). This contradiction increases the instability of international order and causes erosion of trust.

The theoretical contribution of the research relates to the analytical innovation the agro-biological power conceptualization offers to the international relations discipline. The findings demonstrate that traditional power definitions remain limited to military and economic capacities, whereas agricultural biotechnological capacity constitutes a distinctive sovereignty source. Nye's soft power conceptualization proves inadequate in explaining the attractiveness dimension of biotechnological power (Nye, 2004). As participants noted, agro-biological power simultaneously encompasses deterrence, coercion, and persuasion capacities. This multidimensionality constitutes the integrated manifestation in the agricultural domain of the structural and productive power forms

Barnett and Duvall defined in their power typology (Barnett & Duvall, 2005). The agro-security concept proposed by the article expands Buzan's securitization theory and conceptualizes the security-foreign policy connection of agricultural biotechnology (Buzan, Wæver & Wilde, 1998).

The regional bloc formation trends identified in the findings indicate that the global agricultural biotechnology regime is evolving toward a multipolar structure. The biotechnological alliances and regional cooperation networks explained by participants reflect the dynamics in Acharya's norm localization theory (Acharya, 2004). The biotechnology research consortium established by twelve developing countries symbolizes the effort of global south countries to increase collective bargaining power and overcome technological subjugation relationships. While this effort holds potential for opening new negotiation spaces in north-south relations, it risks remaining limited given the depth of structural dependencies. As participants expressed, the technology transfer barriers stem from the domestic politics constraints Moravcsik defined in liberal intergovernmentalism theory (Moravcsik, 1997).

The increasing strategic role of agricultural biotechnology in foreign policy, when evaluated in conjunction with climate change and food security threats, requires structural analysis of legitimacy discourses. As two-thirds of participants noted, the presentation of biotechnological solutions in the context of drought resistance and food crises reinforces technological salvationism discourse. This discourse reflects the hegemony of market-based solutions Bernstein defined in his environmental-liberal governance critique (Bernstein, 2001). The findings demonstrate that equating climate change adaptation policies with biotechnological interventions actually obscures structural causes and shifts political responsibility to the technical domain. As participants expressed, alternative approaches such as agroecology and traditional knowledge systems are kept outside the policy agenda, thereby consolidating biotechnology hegemony. This exclusion practice concretizes the consent production and suppression of counter-hegemonic elements dynamics Gramsci explained in his hegemony theory (Gramsci, 1971).

The research findings support critical perspectives that agricultural biotechnology deepens gender and class inequalities. The access difficulties small-scale producers face regarding biotechnological products, as participants explained, confirm the marginalization processes Patel emphasized in his food sovereignty approach (Patel, 2009). In particular, women farmers' deprivation from traditional seed storage and exchange practices is the result of agricultural policies possessing gender blindness. The exclusion of women from agricultural decision-making processes identified in five countries alongside seed market commercialization points to the reproduction of patriarchal capitalism Mies defined in her ecofeminist critiques (Mies, 1986). The findings necessitate evaluating biotechnological policies from a social justice perspective.

In conclusion, the research findings reveal that agricultural biotechnology has transformed into a distinctive form of sovereignty that can be conceptualized as agro-biological power in foreign policy. Seed diplomacy, genetic hegemony, and biotechnological subjugation relationships deepen the politicization of global food systems and reproduce international inequalities. The structural asymmetries, governance dilemmas, and democratic

accountability crises identified in the findings require urgent structural transformation. Future research must deepen the differentiated effects of agro-biological power along gender, class, and ethnicity axes, make local resistance practices visible, and develop counter-hegemonic agricultural alternatives. Strengthening interdisciplinary cooperation and ensuring epistemological centrality of global south perspectives are imperative for constructing democratic and sustainable global food systems.

7. CONCLUSION AND RECOMMENDATIONS

This study has demonstrated that agricultural biotechnology is not merely an economic or scientific domain of activity, but also a new component of power in contemporary foreign policy. The concept of agro-biological power offers an original theoretical framework for explaining how states establish influence at the global level through their control over biotechnological capacity, food security, and genetic resources. The fundamental finding of the research is that agricultural biotechnology has transformed into a hybrid form of power in contemporary international relations that transcends traditional classifications of soft power or sharp power. The findings reveal that agricultural biotechnology has evolved into a hybrid form of power in contemporary international relations that goes beyond traditional categories of soft power or hard power.

In this context, the first significant conclusion of the study is that biotechnology has now become not only a scientific tool but a central component of foreign policy strategies. Genetically modified seeds, biosafety standards, patent regimes, and food aid mechanisms are producing new networks of dependency and influence among countries. The infrastructural dependency mechanism manifests not only in the commercial dimension of control over seed systems, but also in the form of centralization of production knowledge and erosion of local autonomy (Clapp, 2021; Howard, 2015). In particular, the norm-setting roles of the US, China, and the EU in the field of agricultural biotechnology demonstrate that the concept of global governance has acquired a political rather than technical character.

Second, the study demonstrates that food and biotechnology-based governance now creates an epistemic and normative field of power. States and corporations that are effective in this field determine not only production processes but also the definitions of correct knowledge, safe technology, and ethical standards. The epistemic control mechanism produces structural power relations under the claim of scientificity by monopolizing the discourse of scientific validity; this situation shapes which knowledge will be considered legitimate (Guzzini, 2013; Lemke, 2011). This situation reshapes the geopolitics of knowledge and science, laying the groundwork for the rise of the concept of biotechnology diplomacy.

Third, global cooperation mechanisms in the field of agricultural biotechnology still exhibit an asymmetric power structure. While developed countries occupy a determinative position in terms of technology and financing, developing countries are positioned as providers of biological diversity and raw materials. The normative hegemony mechanism operates through the presentation of biotechnological standards by center countries as universal norms, subjecting the regulatory autonomy of peripheral countries to external pressures (Patel, 2009; McMichael, 2013). This imbalance produces a new biopolitical chain of dependency under the discourse of global governance.

The fourth fundamental conclusion is that digitalization is qualitatively transforming agro-biological power. The articulation of agricultural biotechnology with digital infrastructures creates new layers of control extending from seed dependency to data dependency. Cloud-based agricultural platforms, algorithmic decision support systems, and genetic databases subject producers' autonomous decision-making processes to platform logics; thus, autonomy is voluntarily surrendered under the discourse of technical efficiency (Zuboff, 2019). The determination of data standards and the formation of digital infrastructure protocols constitute new strategic domains of normative hegemony.

The fifth fundamental conclusion is that moments of crisis transform agro-biological power into strategic leverage. The fragility of food supply chains during the global pandemic has provided grounds for states with biotechnological capacity to gain diplomatic effectiveness in the field of food security. The crisis diplomacy mechanism offers opportunities to restructure the regulatory frameworks of recipient countries and create long-term normative dependency through food aid and biotechnology transfer. The agricultural biotechnology investments carried out by the People's Republic of China within the framework of the Belt and Road Initiative embody this strategic logic.

In light of these findings, the following recommendations have been developed:

The concrete guidelines for national policymakers, which constitute the first group of recommendations, are as follows: Developing countries should restructure their [national] agricultural and biotechnology policies not only with the aim of increasing productivity, but with the objectives of strategic autonomy and technological sovereignty. Diversification of seed systems, strengthening of public seed banks, and support for open-access genetic databases are priority steps that will reduce technological dependency. The development of national biosafety regulations should serve as a balancing element that protects national interests while ensuring compliance with international standards. The establishment of regional cooperation networks and the promotion of South-South technology transfer will reduce structural dependency on center countries.

The concrete guidelines for global institutions, which constitute the second group of recommendations, are as follows: International organizations such as FAO, WHO, and WTO should develop new binding mechanisms for transparent information sharing, ethical standards, and fair patent regimes in the field of agricultural biotechnology. Existing regulations concerning the patenting of biotechnological inventions should be reviewed in a manner that will facilitate technology transfer and strengthen the research capacities of developing countries. Ensuring the effective participation of developing countries in decision-making processes within global governance structures is imperative in terms of legitimacy and accountability. The establishment of international protocols concerning the ownership and sharing of digital agricultural data will prevent data exploitation.

The concrete guidelines for academic research, which constitute the third group of recommendations, are as follows: Future studies should test the concept of agro-biological power with quantitative datasets (e.g., patent intensity, research and development expenditures, food export dependency) and increase theoretical depth through comparative country analyses. The deepening of the

differentiated effects of agricultural biotechnology along the axes of gender, class, and ethnicity is critical for understanding global food inequalities. Making visible local resistance practices, agroecological alternatives, and food sovereignty movements will ensure the epistemological centrality of counter-hegemonic perspectives. How the concept of algorithmic governance will be integrated into agro-biological power analysis requires systematic analysis of the transformative effects of digitalization.

The concrete guidelines for societies and civil actors, which constitute the fourth group of recommendations, are as follows: Public awareness regarding agricultural biotechnology should be increased; the political economy and power relations underlying the discourse of scientific progress should be made more visible. Consumer movements, farmers' organizations, and civil society organizations should create organized pressure for the democratization of food systems. Strengthening corporate accountability of biotechnology companies and establishing transparency mechanisms are imperative in terms of democratic oversight. The protection of local knowledge systems and traditional agricultural practices is necessary for maintaining biocultural diversity.

In conclusion, this study emphasizes that agricultural biotechnology is not merely a scientific field but a strategic element shaping the new power architecture of twenty-first-century foreign policy. The concept of agro-biological power offers a powerful theoretical lens for understanding the epistemic and normative struggles that states conduct through food, genetic knowledge, and biotechnological capacity. Seed diplomacy, genetic hegemony, and biotechnological subordination relations deepen the politicization of global food systems and reproduce international inequalities. The structural asymmetries, governance dilemmas, and democratic accountability crises identified in the findings require urgent structural transformation. Therefore, future research should address agricultural biotechnology not merely as production policy but as the biopolitical core of global governance. The construction of democratic and sustainable global food systems necessitates the fair distribution of technological capacities, the democratization of knowledge regimes, and the recognition of epistemic pluralism. The critical analysis of agro-biological power is not only an academic contribution but also the theoretical foundation for developing political projects for egalitarian and emancipatory food futures.

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