

AGRICULTURAL SCIENCE

Helen Anne Curry – *Georgia Institute of Technology*

Suggested Citation: Helen Anne Curry, "Agricultural Science," *Encyclopedia of the History of Science* (October 2025) doi: 10.34758/37vs-v044

Agriculture has a long history. Archaeological research provides evidence of sedentary human communities and cultivation as early as 12,000 years ago. Domestication of plants and animals unfolded slowly thereafter, a piecemeal and patchwork process in which humans and their companion species adjusted incrementally to one another. It's not until 5,000 years ago that the evidence of settled agrarian lives dependent on crops and livestock becomes strong. But even that shortened horizon still points to seven thousand years of agricultural knowledge and practice.¹

Does that mean the history of agricultural science is equally long? Fifty years ago, most historians would have responded to this question with a definitive "no." For these scholars, and many who followed, the origins of agricultural science could be found in the work of European Enlightenment gentlemen improving their estates through experimental trials and in the establishment of state institutions for agricultural research and education.² Today, historians' answers to the same question are likely to be significantly more heterogeneous. They debate the extent and nature of agricultural knowledge and innovation on far more extended timescales and with reference to an array of cultural and geopolitical contexts.³ Some of this scholarship remains focused on elite actors, but not all. Many historians now recognize the ecological and technical expertise of farmers, especially those identified as Indigenous, peasant, or smallholder farmers, and the observational and experimental

¹ Scott, *Against the Grain*.

² E.g., Chambers and Mingay, *Agricultural Revolution*; Rossiter, *Emergence of Agricultural Science*. This characterization refers to English-language literature.

³ E.g., Decker, "Plants and Progress"; Shopov, "Flower Breeding in Early Modern Istanbul." See also Bray et al., *Moving Crops and the Scales of History*.

practices that underpin past and present farmers' choices.⁴ That recognition makes it especially difficult to pinpoint the emergence of a science of agriculture.

This shift in perspective is partly a product of changes in the history of science, especially its broadened view of what counts as scientific knowledge and who is responsible for making that knowledge. But it has also been conditioned by changes in the institutions and practices of agricultural research. Studies that support historians' claims about farmers as sophisticated observers and experimenters often are the products of agricultural social science, for example sociological and anthropological engagement with twentieth- and twenty-first century Indigenous, peasant, and smallholder farming households and communities, or of other disciplines that document situated human knowledge such as ethnobotany and agroecology.⁵ Long marginalized in comparison to chemical, biological, and economic approaches to agricultural "improvement," those domains have made increasing inroads into national and international agricultural research systems since the 1970s. They have also been at the forefront in producing trenchant critiques of these research systems for unhelpfully dismissing farmers' knowledge and relentlessly subordinating farmers to professional scientists.⁶

This entry charts the history of these shifts—that is, of changing ideas about how science relates to agriculture, and scientists to farmers—with a focus on the idealization and implementation of experiments as means of producing agricultural knowledge. Although it points to examples from around the world, the analysis is most robust for the United States and Europe. Many opportunities remain to round out this perspective. Section I charts the institutionalization and professionalization of agricultural research through the early twentieth century, exploring both state and disciplinary aspirations. Section II turns to the internationalization of agricultural research in the era of global development, examining the geopolitical circumstances that favored professional scientists' knowledge over that of farmers. Section III tracks new conceptualizations of farmers' expertise emerging from critiques of international agricultural development and the emergence of research programs that center farmers' labor and knowledge as essential to sound agricultural science.

⁴ E.g. Osorio, "Why *Chuño* Matters"; Conway, "Rural Indians and Technological Innovation"; Stunden Bower, "Women's Garden Work." With reference to experiments specifically, see Maat, "History and Future"; Harwood, "Comments on Experimentation."

⁵ E.g. Richards, *Indigenous Agricultural Revolution*; González, *Zapotec Science*; Altieri, *Agroecology*.

⁶ Wezel et al., "Agroecology as a Science." See also contributions to the special issue on the history of agroecology, *Agroecology and Sustainable Food Systems* 41, issue 3–4 (2017).

INSTITUTIONALIZATION AND PROFESSIONALIZATION OF AGRICULTURAL SCIENCE

Histories of agricultural science have often started with the activities of landowning “improvers”—and with good reason. By delineating and promoting “scientific” approaches to farming, these cultivators set in motion processes by which a domain of agricultural science came to be distinguished from agriculture itself. This delineation, sharpened by the creation of institutions for agricultural research and education and by the professionalization of plant and animal breeders, soil chemists, and other agricultural scientists, was accompanied by a shift in authority from some knowers to others. If indeed cultivators can be credited with launching what is thought of today as agricultural science, their success can be measured in cultivators’ ever-greater exclusion from that very space. This section begins with a look at agricultural science prior to the nineteenth century and then describes the growth in institutions of agricultural science from the mid-nineteenth century onward. It highlights changing ideas about the nature and value of agricultural experiments and especially about the identity of an experimenter whose results could be relied upon.

For centuries, the production and circulation of agricultural knowledge has been shaped by transit and trade, patterns of land ownership, the distribution of agricultural labor, and state interest in agricultural production. In an account of agronomic science in late imperial China, covering the period from 1250 to 1650, the historian Francesca Bray identifies different categories of knowledgeable actors who produced distinctive contributions to the science of managing agricultural soils, plants, and animals. Officials of imperial institutions tasked with the promotion of agriculture—seen as necessary to fill state coffers and maintain social harmony—sought to identify good practices that could be generalized across the vast and heterogenous terrain of the empire and to circulate these practices through texts and demonstrations. Educated landowners, typically concerned with the management and productivity of their own properties, sought to explore and publish locally effective adaptations of existing ideas and approaches. Rent-paying tenants or smallholder peasant farmers, those whose welfare was most immediately dependent on the success or failure of the harvest, were both cast as the beneficiaries of the circulation of agronomic knowledge and often acknowledged as reliable sources of the same.⁷

The differentiation in production and attribution of agricultural knowledge across social groups with different access to property and power that Bray identifies in late imperial China is not unique to that historical setting. The rough categories of professionalized (typically also state) agents, invested private owners, and skilled laboring farmer-observers repeat across time and place. Yet the distribution of credit and authority among these groups has been anything but fixed. Of these distinct social groups, it is peasant or smallholder farmers—those closest to soils and seeds and most vulnerable to farm-level successes or

⁷ Bray, “Science, Technique, Technology.”

failures—whose role in possessing and producing reliable knowledge historically has been subject to the greatest debate.

This becomes evident with a shift in attention from the agrarian knowledge economy of late imperial China to that of eighteenth-century Europe, where agricultural societies emerged and agricultural publishing newly flourished amid vigorous interest in discovering and disseminating novel techniques for crop production and livestock raising.⁸ The historian Mario Ambrosoli shows landowning British agricultural improvers of fifteenth and sixteenth centuries to have turned initially to classical texts on agronomy and botany in search of knowledge that would help them manage their estates.⁹ To the observations of centuries past and places distant, they soon added accounts based on their experiences of cultivating their own lands or practices they had seen or learned through travel and correspondence. By the eighteenth century, elite improvers with access to land, labor, and money reported the outcomes of their independent studies—whether comparisons of crops, successes and failures of manuring, or some other inquiry—in the increasingly robust agricultural press or in agricultural and economic societies founded in part with the aim of generating and sharing farming know-how.¹⁰

In Britain, often pinpointed as a center for transformations in agricultural practices such as selective breeding and crop rotation, agricultural societies expanded from about a dozen by the 1780s, initially concentrated in Scotland, to more than 220 across England and Scotland by 1835, to some 700 by 1870. British agricultural publishing similarly expanded, in both sheer quantity of material as well as the diversity of kinds, from encyclopedias and treatises to periodical journals and newspapers, all attending to the concerns of farming.¹¹ Charting the mushrooming of agricultural societies and burgeoning of agricultural writing across wider Europe, the historian Peter Jones illustrates a sustained intellectual engagement in the perceived imperative of agricultural “improvement” or “progress” that united authors, statespersons, landowners, and farmers across the continent from the mid-1700s to the mid-1800s.¹² As Jones notes, this intellectual efflorescence was associated with critical transformations in European politics, economy, and demography. Population growth in Europe necessitated greater agricultural productivity, and the draining of state coffers to

⁸ For a study that traces the development of agricultural knowledge in Europe in the intervening period, from the fourteenth to seventeenth centuries, see Ambrosoli, *Wild and the Sown*.

⁹ Ambrosoli, *Wild and the Sown*, ch. 5.

¹⁰ Jones, *Agricultural Enlightenment*, 68–70. See also Wilmot, “Business of Improvement”; Pawley, *Nature of the Future*.

¹¹ Wilmot, “Business of Improvement,” 9–11.

¹² Jones, *Agricultural Enlightenment*. On the US context, see Pawley, *Nature of the Future*; on Italy, see Fagnani, *Development of Agricultural Science*.

sustain military engagements encouraged European powers to attend more closely to the rural economy.¹³

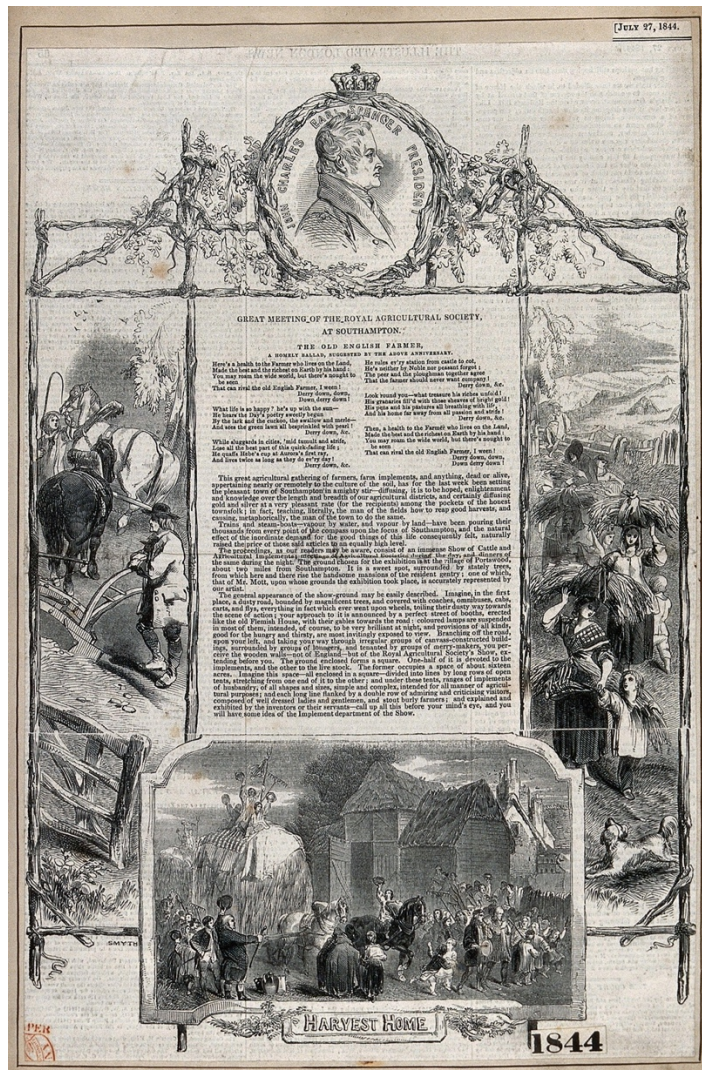


Figure 1: Newspaper coverage of the Great Meeting of the Royal Agricultural Society, at Southampton, England, 1844. Wellcome Collection. <https://www.jstor.org/stable/community.24847576>.

According to Jones, this surge in agricultural inquiry and debate emerged in relation to a more general confidence in the knowability of the natural world through observation and experiment, as well as the convergence of government officials, landowners, and scholars in

¹³ Jones, *Agricultural Enlightenment*, ch. 2.

the desire to enhance farm productivity.¹⁴ But a convergence in this overarching goal did not necessarily mean a convergence in the methods of achieving that goal. How could one know with confidence which livestock breeds, crop varieties, soil treatments, or cultivation methods would result in the best outcomes? Improvers of the eighteenth and nineteenth centuries unsurprisingly held diverse views on what practices were most likely to enhance farm productivity and profitability. They also debated the means of deciding on a best practice from among the options available.

Early aggregators and disseminators of agricultural knowledge in Europe drew on, and sometimes acknowledged, the labor and experiences of peasant farmers, and shared those farmers' insights into animals, plants, and soils.¹⁵ But historians identify two successive trends with respect to who could be considered a reliable authority on agricultural matters. Sarah Wilmot, considering transformations in Britain, identifies a period from the late-eighteenth to early-nineteenth century in which the "enlightened leadership of landlords" and their pursuit of experiments was thought necessary to shake "common farmers" "out of age-old practices and put agriculture on new scientific foundations."¹⁶ In this view, peasant cultivators were the possessors of outdated knowledge at best and unlikely to be the producers of experimentally verified insights now so eagerly sought.

By the mid-nineteenth century, the knowledge and skills of gentlemen farmers had also come to be questioned. Along with peasants, Wilmot writes, "[l]andowners were similarly portrayed as in need of enlightenment by external influences; no longer flattered as the 'natural leaders' of the scientific revolution in agriculture, suggestions [were] numerous for their educational training." Their experiments were likewise devalued in favor of work carried out by a growing number of natural philosophers with knowledge of agricultural topics, who could be commissioned by agricultural societies to resolve their questions through experiments.¹⁷

An early and influential incursion of such expertise into agricultural discussions centered on the application of chemical knowledge on the farm, especially with respect to soil fertility. Academic treatises such as the British chemist Humphrey Davy's 1818 *Elements of Agricultural Chemistry* attempted to bring the insights of the laboratory to the field; however, as Peter Jones observes of Davy, "his understanding of agriculture and soils was not commensurate with his knowledge of chemistry."¹⁸ More successful in winning adherents was Justus von

¹⁴ Jones, *Agricultural Enlightenment*, 6.

¹⁵ Ambrosoli, *Wild and the Sown*; Fagnani, "Studying 'Useful Plants'"; Phillips, "Socrates on the Farm."

¹⁶ Wilmot, "Business of Improvement," 14–15.

¹⁷ Wilmot, "Business of Improvement," 19–20, 34.

¹⁸ Jones, *Agricultural Enlightenment*, 164.

Liebig, a German chemist whose 1840 *Organic Chemistry in its Application to Agriculture and Physiology* (*Die Organische Chemie in ihrer Anwendung auf Agricultur und Physiologie*) argued that knowledge gained in the chemical laboratory could be used—indeed *had* to be used—to understand and improve soils. In his view, farmers' experiences could not compete with laboratory analyses when it came to ameliorating poor soils or sustaining fertility. Quickly translated into English and French, Liebig's work was widely discussed, embraced by some but contested or dismissed by others.¹⁹ The historian Margaret Rossiter argues that Liebig's most enduring effect on agriculture in the United States, where he was typically favorably received, was in galvanizing chemists to exercise new authority in agricultural matters and especially to build institutions for agricultural science.²⁰



Figure 2: A 1920s advertisement celebrating the nineteenth-century chemical laboratory of Justus von Liebig in Giessen. Courtesy of Science History Institute. <https://digital.sciencehistory.org/works/st74cr668>.

Institution building, not only in the United States but across the globe, would create dedicated experimental spaces—whether laboratories or experimental stations—that supplanted estates and farms as the sites of agricultural knowledge production. In Europe, the study of plants, initially associated with the practice of medicine, had emerged as a discipline of its own in the seventeenth century, giving botanical experts increasing access to

¹⁹ Jones, *Agricultural Enlightenment*, 182–85.

²⁰ Rossiter, *Emergence of Agricultural Science*. See also Pawley, “Accounting with the Fields.”

university positions and botanical gardens. Yet their study of botany was not necessarily associated with knowledge of cultivation.²¹ Agitation in Europe for university positions in agriculture and the provision of training in husbandry and agronomy had produced a handful of chairs and courses of instruction by the early nineteenth century. From the 1840s through the early twentieth century, state and imperial interest in building agricultural capacity, together with the interest of professional scientists in claiming knowledge relevant to that project, facilitated the emergence of agricultural colleges and experiment stations.²²

Initially, these institutions did not represent a decisive break from the agricultural research traditions that preceded them. An institution considered the first state-funded agricultural experiment station was established on the Möckern estate in Saxony in 1850. It was instigated by a landowner, Wilhelm Crusius, who was president of Saxony's oldest improvement society, working with a university professor of agricultural chemistry and a state agricultural minister. Crusius was not persuaded by the likes of Liebig that laboratories alone held the answers to farming concerns, instead seeing the estate as a place where the knowledge most useful to farmers would emerge. At the Möckern station, comparative field experiments would allow for more useful insights than either the laboratory or a farmer's individual field trial would allow. In other words, Crusius and his colleagues bridged the tradition of on-farm, landowner-led knowledge making and the newer impulse for laboratory-derived results.²³

In time, state agricultural experiment stations would become more decisively spaces for agricultural professionals who were not cultivators but scientists to exercise their authority. They would not only determine the solutions recommended to farmers, but also set the questions.²⁴ In the United States, where chemists had eagerly followed up on the teachings of Liebig, aspiring professional scientists pressed for institutional investment. With lawmakers eager to demonstrate support for their rural constituents, a new state and federal research infrastructure took shape in the late nineteenth and early twentieth century.²⁵ In 1862 the federal government passed legislation to create a US Department of Agriculture (USDA), which would be authorized to hire scientists when needed, and provided land grants to each state for the purpose of establishing a state college of agriculture. In 1887 the federal

²¹ Easterby-Smith, *Cultivating Commerce*, 6–10.

²² For an overview of this institution building, see Anderson, "Growing Power of Agricultural Science."

²³ Finlay, "German Agricultural Research Stations." The case of the variable "drift" of German agricultural institutions toward research over practice is explored in Harwood, *Technology's Dilemma*. Assessing Circumstances in China, Lavelle makes a case for continuity of new agricultural institutions with older forms of agricultural communication in Lavelle, "Placing the Science of Agriculture."

²⁴ Marcus, "Historians' Corner." See also Danbom, "Agricultural Experiment Station and Professionalization"; Ferleger, "Uplifting American Agriculture."

²⁵ Rossiter, *Emergence of Agricultural Science*; Rosenberg, *No Other Gods*.

government passed a bill authorizing funding for state experiment stations, and a year later the USDA opened its Office of Experiment Stations to coordinate and disseminate research across these stations. In the early twentieth century, in recognition of a yawning gap between farmers and professional researchers, agricultural extension was formalized as the route through which science would make its way from within this bevy of institutions to the farm gate. The historian Alan Marcus aptly summarizes the consequences of this US agricultural research apparatus and the status it afforded scientists over agriculture. Science, he writes, “had become *the* prime mover and fundamental determinant of agricultural practice. Farmers, formerly a seemingly independent group... now needed agricultural science merely to function somewhat successfully as farmers. They had become a dependent class.”²⁶



Figure 3: A farmer studies a display of sorghum types at the US Dryland Experiment Station in Akron, Colorado, 1939. Photo by Arthur Rothstein for the US Farm Security Administration. US Library of Congress LC-USF33- 003375-M2. <https://www.loc.gov/pictures/item/2017726265/>.

The rapid expansion of institutions for agricultural science and education across national contexts in the late nineteenth and early twentieth century is striking. From the initial state sponsorship of the experiment station at Möckern, stations dedicated to producing knowledge relevant to agricultural production mushroomed across Germany; by 1889, there

²⁶ Marcus, “Historians’ Corner,” 162.

were 63 stations employing more than 70 directors and over 200 scientists.²⁷ The Belgian government, concerned about domestic food shortages and falling behind neighboring countries, began investing in state agricultural schools and agricultural laboratories in the 1860s.²⁸ Leaders of the Russian Empire, facing public outrage following the great famine of 1891–1892, sought out scientist advisors and launched a network of experiment stations to quell unrest and forestall future crises.²⁹ In China, institutions linked to agricultural science proliferated across the country after 1900 in response to pressure for government reforms.³⁰ Clearly diverse state authorities had been persuaded that investments in agricultural knowledge would lead to greater farm productivity—and that greater farm productivity was a source of government legitimacy and state power.

AGRICULTURAL SCIENCE AND INTERNATIONAL DEVELOPMENT

In the late-nineteenth and early-twentieth centuries, governments afforded new authority to professional scientists in shaping agricultural trajectories and sponsored institutions that gave those scientists platforms for their work. Many governments unsurprisingly also recognized the value of such institutions and their scientific staff in projecting state power across borders or overseas, first through formal empire and later through foreign aid and development programs. This section opens with a consideration of the role of agricultural science in empire from the late nineteenth century through the 1930s. The knowledge of farmers in colonized lands typically was marginalized or ignored in the implementation of extractive production regimes intended to bring wealth to imperial powers; here agricultural science was an instrument for control of both people and production. After examining these patterns, the section then turns to the postwar decades, charting the era of decolonization. It discusses “global development” as the new framework for judging the (in)adequacy of farmers’ knowledge and justifying international institutions for agricultural research and training.

Scholars have developed an impressive body of knowledge about the mutually beneficial entanglement of science and empire, highlighting the essential role of botanical, agricultural, and horticultural experts in the forging of imperial power. From the sixteenth century, successful transfers of plants and seeds across the globe—feats that in many cases demanded knowledge and skill possessed both by local actors and imperial agents—were

²⁷ Ferleger, “European Agricultural Development.” See also Finlay, “Science, Practice, and Politics”; Harwood, *Technology’s Dilemma*.

²⁸ Diser, “Laboratory versus Farm.”

²⁹ Elina, “Planting Seeds for the Revolution.”

³⁰ Lavelle, “Placing the Science of Agriculture.”

essential to extracting colonial resources for imperial gain.³¹ Botanical gardens accrued power and visibility as key sites for developing imperial knowledge of novel flora and for moving plants to places where they might generate wealth for planters (and by extension imperial powers) or facilitate settler colonies.³² Owners and managers of plantations sought to develop the know-how needed to sustain their enterprises by consulting experts and their publications or through experiments of their own.³³

The wave of institutionalization in agricultural science of the late-nineteenth and early-twentieth centuries also reshaped the institutions of empire. Colonial authorities recruited scientists to new experiment stations and agricultural ministries and charged them with leading research on both food and commodity crops. In the Dutch East Indies, the botanical garden Buitenzorg on Java had played a role in the collection and evaluation of tropical plants from its founding in 1817. In 1905, the botanical garden was incorporated into a new Department of Agriculture and tasked with studies of rubber, coffee, cinchona, and other plantation products (previously attended to by planter-funded associations) as well as increasing rice production for local consumption.³⁴ The latter, it should be noted, was as crucial to the colonial enterprise as understanding coffee diseases and the chemistry of cinchona: the rice crop sustained plantation laborers and, moreover, was taxed to generate revenues.

³¹ Useful entry points into this literature include: Schiebinger and Swan, *Colonial Botany*; Batsaki, Calahan, and Tchikine, *Botany of Empire*.

³² Brockway, *Science and Colonial Expansion*; Drayton, *Nature's Government*; Baber, "Plants of Empire."

³³ See examples in Kumar, "Plantation Science," 551; Van der Schoor, "Pure Science and Colonial Agriculture." Private corporations continued in this tradition, see, e.g., McCook, *States of Nature*, 60–63.

³⁴ Maat, *Science Cultivating Practice*.

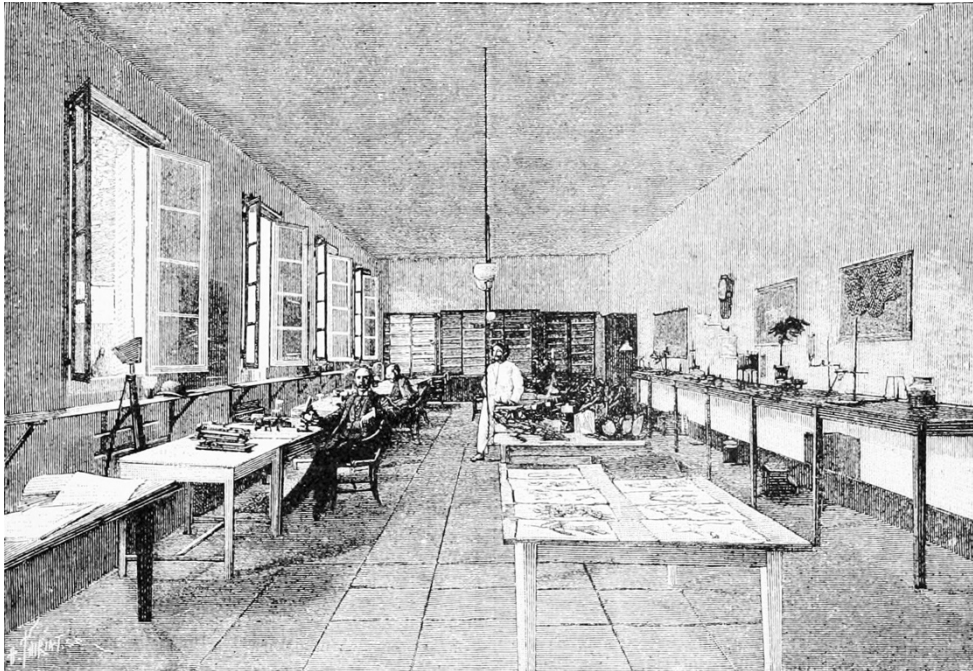


Figure 4: Laboratory of the Botanical garden at Buitenzorg, 1890s. *Popular Science Monthly* 48 (January 1896) via Wikimedia Commons.

A similar pattern can be observed across empires. Botanical stations understood to have responsibilities for examining agricultural resources appeared in a flurry across tropical British Africa between 1887 and 1898: Lagos, Gold Coast, Niger Coast, Gambia, Sierra Leone, British Central Africa, and the East Africa Protectorate.³⁵ In Senegal, the Department of Agriculture launched by the French colonial government in the 1890s gathered power and prestige as an information-gathering hub and supervisory agency in the years leading up to World War I.³⁶ As Japan extended its empire to Taiwan and Korea, it also extended its nascent state agricultural services to these colonies, anticipating a payoff in rice productivity to fuel workers on the Japanese archipelago.³⁷ And so on.

Historians identify an important shift in the agendas imagined for agricultural science among European colonial authorities beginning in the 1930s, which was ultimately accompanied by renewed investments in the coordination of agricultural research. The prioritization of export commodity cultivation was increasingly challenged by the idea, motivated by perceived environmental degradation and concerns about poverty and public health, that it

³⁵ Tilley, *Africa as a Living Laboratory*, table 3.1. See full discussion of the history of British colonial agricultural science in Hodge, *Triumph of the Expert*.

³⁶ Bonneuil, "Penetrating the Natives."

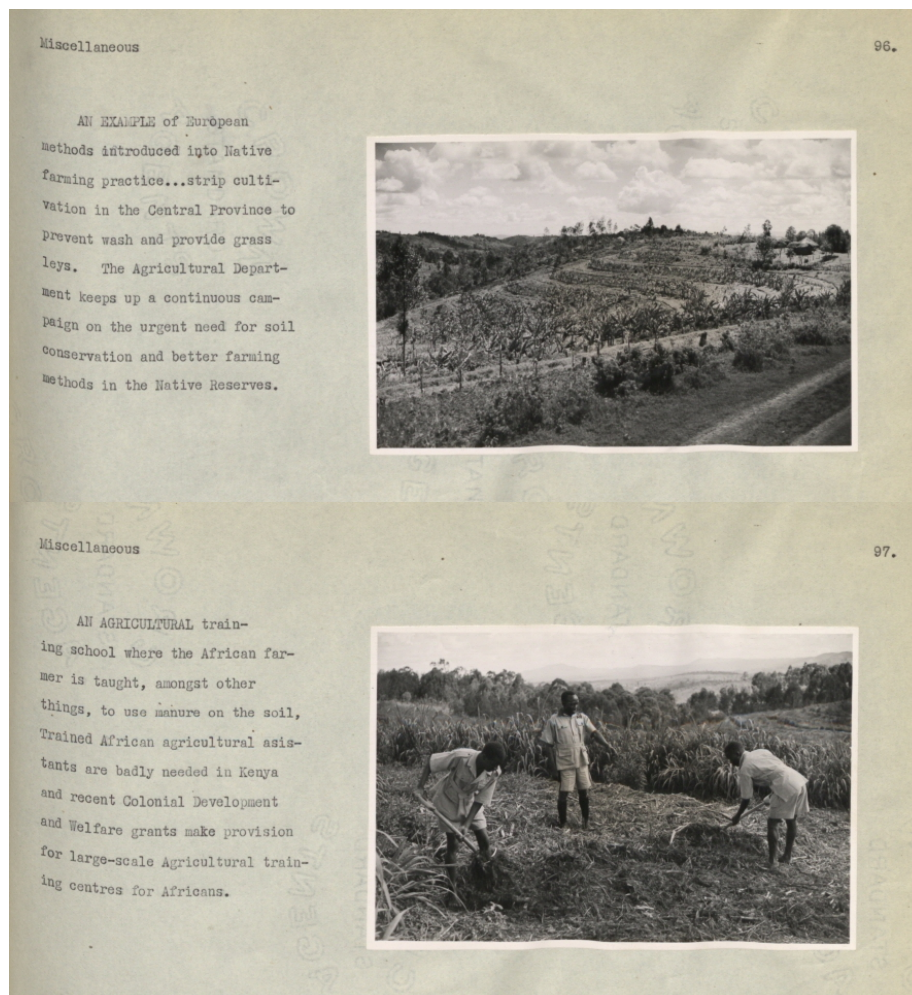
³⁷ Wang and Buck, "Relocating Agrarian Development."

was essential to better understand colonial environments and to intervene in agricultural practices more oriented towards local subsistence and income. Ecological knowledge would stabilize the landscapes essential to continued productivity. Meanwhile “modernizing” agriculture through the introduction of new seeds, breeds, tools, and techniques would engender healthy, peaceable, self-sustaining colonial subjects.³⁸

British Africa offers a useful example. In the 1920s, government leaders, persuaded of the role of science in fomenting agricultural production, attempted to bring new order and energy to the scattered colonial agricultural services. Founded in 1929, the British Colonial Advisory Council on Agriculture and Animal Health initially sought to unify these services and to create a network of colonial research stations with a focus on commodity-based research. Stymied in its ambitious plans by the financial constraints of the Great Depression, its work proceeded only piecemeal through the early 1930s. By the end of the decade, it had pivoted to the emerging concerns of soil erosion and declining rural welfare. “Native” farmers were characterized as lacking the knowledge and tools necessary to generate higher productivity from the lands they cultivated; their shifting cultivation practices were blamed for environmental degradation. To many British advisors, the only solution was the expert-led reorganization of African agricultural communities and the adoption of European cultivation practices.³⁹

³⁸ Bonneuil, “Development as Experiment”; Tilley, *Africa as a Living Laboratory*; Hodge, “Science, Development, and Empire.”

³⁹ Hodge, “Science, Development, and Empire.”



Figures 5 and 6: Two pages from a photobook of British colonial Kenya now held in the UK National Archives summarize the typical British perspective on local farming practices as inadequate and in need of “better” methods introduced by colonizers. Kenya, 1940s or 50s. UK National Archives CO 1069/137. <https://www.flickr.com/photos/nationalarchives/albums/72157625974571006/>.

This imperial perspective on the inadequacies of African farmers to successfully manage their lands for agricultural productivity proved auspicious for large-scale interventions. In charting commonalities among ambitious British, French, and Belgian irrigation, re-settlement, and mechanization schemes from the 1930s through the 1960s, the historian Christophe Bonneuil observes that they placed experts, typically scientists, in charge and stimulated the creation of new technical and research agencies.⁴⁰ In other words, they further amplified the authority of scientists in colonial projects, including over subjugated peoples. Bonneuil further notes the extent to which they made African farmers a part of large-scale experiments: “In many ways, settlement schemes were up-scaled agricultural-

⁴⁰ Bonneuil, “Development as Experiment.”

station programs. Often established near a preexisting research station, they were generally set up to experiment with technical recipes proposed by scientists in such areas as new varieties, new crop rotations, and new tools."⁴¹ Not only were farmers excluded from the ranks of those who could possess or produce experimentally verified knowledge, they were themselves now subjects of scientists' experiments.

Although identified most readily as an instrument of control or subjugation in colonial settings, agricultural science at times played this role in domestic policy as well. The historian Tiago Saraiva demonstrates that crop varieties and animal breeds engineered by scientists were the means of implanting state control (as well as tools of colonial expansion) for fascist regimes in Germany, Italy, and Portugal in the early-to-mid twentieth century. For authoritarian leaders who sought national strength through economic self-sufficiency (autarky), the imperative of domestic food production loomed large and created opportunities for agricultural scientists and institutions to intervene in farmers' lives in unprecedented ways. In Germany under National Socialism, for example, breeders associated with state research institutions developed varieties deemed to have superior productivity; their cultivation was then mandated through variety lists that specified what types farmers could grow and bans on alternative varieties.⁴²

Almost regardless of setting, institutions of agricultural science by the mid-twentieth century had become associated with a narrow conception of agriculture: centered on monocultural production of "improved" varieties, emphasizing standardization and uniformity of the product, deploying mechanization where possible, often dependent on inputs of fertilizer and irrigation, and emphasizing yield as the chief measure of success.⁴³ Farmers who had not adopted these strategies may have been characterized as "peasant," "traditional," "primitive," or "backward"—but in all cases were understood as not having benefitted from the insights of "modern" agricultural knowledge and technology. This characterization of smallholder and subsistence farmers as lacking the knowledge and skills required for "modern" agriculture became a more sustained component of global political discourse and action in the decades following World War II.

The war completely upended farming and food systems across Europe and in Japan.⁴⁴ American political leaders ensured that US farmers' agricultural products, supplied in a steady stream to the Allied nations through the Lend-Lease program during the conflict, would continue to be a critical facet of postwar reconstruction programs and an important

⁴¹ Bonneuil, "Development as Experiment," 271.

⁴² Saraiva, *Fascist Pigs*.

⁴³ Fitzgerald, *Every Farm a Factory*; Smith, *Works in Progress*. On the fate of peasant-friendly agricultural research, see Harwood, *Europe's Green Revolution*.

⁴⁴ Collingham, *Taste of War*.

negotiating tool in diplomatic relations.⁴⁵ The ability to flex farm productivity as “food power” in international affairs played a significant role in US leadership scuttling international efforts to coordinate global food distribution through the UN Food and Agriculture Organization (FAO), which was established in 1945. Aspirations within FAO for a “World Food Board”—a body that would have the authority to stabilize agricultural commodity prices, maintain a world food reserve for distribution to countries in crisis, and provide funds to facilitate food redistribution from countries with surpluses to those in need—ran up against strong opposition from the United States as well as Great Britain and the Soviet Union. These countries saw strategic national advantages in the continuation of inequitable access to food.⁴⁶

The alternative to intervening in markets to directly address hunger was the provision of technical aid to increase crop production by those deemed agricultural experts. As the geographer Lucy Jarosz summarizes, “Guided by the knowledge and power of science and the disciplines of economics and nutrition, Western experts could devise ways to feed the world.”⁴⁷ In other words, experts financed by aid-giving nations would be dispatched to instruct farmers and agricultural workers of aid-receiving nations on how best to farm. Emphasis on productivity-focused technical aid not only forestalled direct interventions in food commodity markets but also stymied agrarian reform and related efforts to address inequality in access to food through redistribution of land.⁴⁸ Technical aid was the only option palatable to those already possessing political and economic power. It would become the prevailing strategy for FAO in dealing with global food and agricultural crises as well as the agricultural aid model adopted by the World Bank and by many national foreign aid programs.

⁴⁵ McDonald, *Food Power*.

⁴⁶ Jarosz, “Political Economy of Global Governance”; Staples, *Birth of Development*.

⁴⁷ Jarosz, “Political Economy of Global Governance,” 42.

⁴⁸ Guldi, *The Long Land War*.



Figure 7: An instructor from the UN Food and Agriculture Organization (FAO) demonstrates a laboratory-grade machine for rice milling at a National Centre for Grading and Inspection of Rice organized by FAO in Bangkok, Thailand, ca. 1950. © FAO and used by permission.

The ideal of farming emphasized in Cold War technical aid missions through the 1970s was almost invariably the same industrial model orientated to the production of commodities for the commercial market that was championed by established national agricultural research and extension systems.⁴⁹ Farmers were encouraged to plant varieties developed by professional breeders to prioritize yield, to raise recommended animal breeds, to invest in mechanization, and to apply synthetic fertilizers; states were encouraged to welcome foreign seed, equipment, and fertilizer businesses and to build irrigation infrastructures. In the United States, early state-sponsored Cold War technical aid missions to Latin America, Asia, and Africa were coordinated through the nation's agricultural universities, with American agronomists, breeders, and other scientists serving as essential vehicles for knowledge, not only about farming but also about the creation of agricultural research and training infrastructure.⁵⁰

The building of in-country scientific infrastructure was also an important component of US private philanthropic agricultural missions in the Cold War. The Rockefeller Foundation, which had engaged in foreign agricultural aid since the early twentieth century, launched an

⁴⁹ Harwood, "Was the Green Revolution Intended to Maximize Food Production?"; Patel, "Long Green Revolution."

⁵⁰ Kumar, "Modalities of Modernization."

agricultural program in Mexico in 1943 in cooperation with the Mexican government. Administered and led by US agricultural scientists (with training at US land grant institutions), the program aimed to produce knowledge and techniques immediately useful to Mexican production and to enhance the scientific training of Mexican agronomists.⁵¹ Its earliest consultants and staff were experts in plant breeding, crop pests and diseases, and soil science. The implication was not just that these expert domains were essential to progress in agriculture but also that local scientists and institutions fell short of the standards expected for effective research and education.



Figure 8: Research station workers examine the results of a poblano chili pepper breeding study at the “El Horno” agricultural experiment station in Chapingo, Mexico, ca. 1950s. Rockefeller Foundation records, Photographs, Series 323, Agriculture - Experiment Stations - Chapingo - Beans, circa 1905-1980, Rockefeller Archive Center, <https://dimes.rockarch.org/objects/Eoj36bbujY2gK6iX2YkCrA>. Used by permission.

The Mexican government’s welcoming of Rockefeller Foundation funds to support agricultural science, with the promise of placing Mexican farming on a pathway to the production model prevailing in the United States, should not be overlooked. Histories of Cold War agricultural aid programs long described these almost exclusively as instruments of domination wielded by the minority world over the majority world. More recent accounts emphasize the nationalist agendas that invited foreign resources seen as essential to economic “modernization,” especially in countries newly independent following the wave of

⁵¹ Perkins, *Geopolitics and the Green Revolution*; Cullather, *Hungry World*; Olsson, *Agrarian Crossings*; Baranski, *Globalization of Wheat*.

decolonization from the late 1940s through the 1960s.⁵² For example, as the historian Prakash Kumar shows, Indian ambitions for modernization determined the contours of the country's agricultural interventions across the twentieth century, from colonial development efforts to postcolonial aid programs to transnational scientific research infrastructures.⁵³

Recent scholarship also emphasizes the significant existing local scientific capacities on which successful technical aid programs built and the ways in which these local capacities became the foundation of new transnational exchanges.⁵⁴ Well before the Rockefeller Foundation extended its agricultural aid to Colombia in the 1950s, imagining itself the deliverer of modern science to a nation in need, Colombian scientists and domestic institutions had already launched the nation on its pathway to agricultural industrialization, as the historian Timothy Lorek has shown.⁵⁵ In Brazil, the state-owned agricultural research corporation Embrapa was established in 1972 and soon set Brazil on a trajectory of profound agricultural transformation. The development sociologist Ryan Nehring situates Embrapa's origins in the efforts of Brazilian agricultural experts and technocrats to ensure Brazilian-led agricultural development in their country in the face of looming US impositions. Embrapa eventually established dominance in the pursuit of agricultural research for the tropics more generally, facilitating the dissemination of its seeds and technologies across Latin America and Africa.⁵⁶

Another important corrective to histories of the Cold War "age of development," which tended to emphasize the role of US actors in inaugurating this "new" approach to international aid focused on economic and social modernization, showcases instead significant continuities between colonial and postcolonial ideas about and approaches to development. These continuities include the expert workers behind development. The historian Joseph Hodge charts the common experience of British colonial agricultural officers and other technical workers moving to positions in international development programs following successful movements for national independence.⁵⁷ Hardly rendered irrelevant by the decline of empires, former colonial agents were eagerly sought after by aid programs for their overseas experiences. Hodge locates former British colonial agricultural officers overwhelmingly in later positions at the World Bank, UN FAO, British foreign aid agencies,

⁵² E.g., Olsson, *Agrarian Crossings*; Kumar, "US-India Entanglements"; Saha, "Food for Soil."

⁵³ Kumar, *A History of India's Green Revolution*.

⁵⁴ E.g. Lorek, *Making the Green Revolution*; Soto Laveaga, "Socialist Origins"; Nehring, "Brazilian Green Revolution"; Chu, "Harvesting Diversity."

⁵⁵ Lorek, *Making the Green Revolution*.

⁵⁶ Nehring, "Brazilian Green Revolution." See also Nehring, "The Technopolitics of Agronomic Knowledge"; Nehring, "Yield of Dreams."

⁵⁷ Hodge, "British Colonial Expertise." See also Hodge, *Triumph of the Expert*.

and other national and international organizations working in the development space.⁵⁸ Having forged their careers during the period when settlement schemes and other large-scale interventions sought to "modernize" agriculture and society in colonial sites, these individuals found their established "faith in the superiority of technical 'know how' over traditional ways" welcomed in and often essential to the infrastructure of international development through the late twentieth century.⁵⁹

International agencies, foreign aid programs, state-building initiatives, and philanthropic efforts combined to produce impressive mechanisms for extending the "technical know-how" of industrialized agriculture and its material components (seeds, animals, fertilizers, equipment, loans) to farmers considered in need of these. Geographically constrained projects like settlement schemes and irrigation projects were complemented by efforts to develop networks through which knowledge and expertise would be shared across sites. Early postwar collaborations between the US Department of Agriculture and the UN FAO saw the development of a research network dedicated to developing and distributing hybrid maize seeds across Europe and the Mediterranean, an international wheat rust research and response initiative, and an international rice breeding effort.⁶⁰ On the heels of its involvement in Mexican agricultural research capacity, and increasingly motivated by concerns about global population growth and the political instability that might result from shortages of food and other resources, the Rockefeller Foundation launched comparable collaborations with national governments to support agricultural research, initially elsewhere in Latin America and soon thereafter in India.⁶¹

From the 1950s, foundation administrators and political leaders such as Ricardo Acosta of Mexico began to imagine research institutions that were international rather than national in orientation. Together with the Ford Foundation, the Rockefeller Foundation created the International Rice Research Institute (IRRI) in the Philippines in 1960, imagining a centralized research hub where the problems of rice cultivation common to many countries could be tackled. Later in the 1960s, an assemblage of national and regional research sites that had emerged from collaborations of the Rockefeller Foundation, FAO, and Mexican government and Ford Foundation projects were united to form the International Wheat and Maize

⁵⁸ Hodge, "British Colonial Expertise," 26.

⁵⁹ Hodge, "British Colonial Expertise," 39. This is Hodge's characterization of the views of Robert McNamara of the World Bank, which he argues was widely shared among British colonial officers.

⁶⁰ Byerlee and Lynam, "Development of the International Center Model," 3–4.

⁶¹ Lorek, *Making the Green Revolution*; Kumar, *History of India's Green Revolution*.

Improvement Center (CIMMYT, Centro Internacional de Mejoramiento de Maíz y Trigo) in Mexico.⁶²



Figure 9: Rice cultivation in the experimental fields of the International Rice Research Institute, Los Baños, Philippines, 1962. International Rice Research Institute - IRRI - Rice Fields, circa 1905-1980, Rockefeller Foundation records, Photographs, Philippines - Natural Sciences and Agriculture, Subseries 242D; Rockefeller Archive Center; <https://dimes.rockarch.org/objects/hsbUKA3FqaxZDNZumpgbXz>. Used by permission.

IRRI and CIMMYT succeeded in developing disseminating widely-adapted, fertilizer-responsive varieties of rice and wheat, achievements often described as the start of the “Green Revolution” in agriculture. The idea of the Green Revolution was eagerly grasped by its mostly capitalist proponents as an alternative to the “red” revolutions they imagined might arise among restless, hungry peasants in countries facing food scarcity. Many also thought that higher yields would buy time for what they saw as a more lasting solution to global hunger: population control.⁶³

The successes of CIMMYT and IRRI paved the way for other international agricultural research centers to take shape in the 1960s and 70s. Many of these centers built on or emerged from prior institutional investments, including colonial and national research operations. Their loose coordination from 1971 under the auspices of a Consultative Group

⁶² Byerlee and Lynam, “Development of the International Center Model,” 6–7. See also Curry and Lorek, *Agricultural Science as International Development*.

⁶³ Cullather, *Hungry World*.

on International Agricultural Research (CGIAR) spearheaded by the World Bank strengthened their claims to producing globally relevant agricultural knowledge.⁶⁴ CGIAR was tasked with fostering scientific research that would help “developing nations ... increase and improve the quality of their agricultural output.”⁶⁵

A foundational premise for the creation of international agricultural research centers was the idea that what kept many farmers and rural communities in poverty was lack of technical knowledge and inadequate seeds, animals, tools, and inputs—and that this insufficiency could be addressed through the efforts of professional scientists committed to “research excellence” based in dedicated research facilities.⁶⁶ The go-to example was Norman Borlaug, a scientist from the US Midwest hired in 1944 to lead the wheat breeding program of the joint Rockefeller Foundation–Mexican government initiative. Borlaug was awarded the Nobel Peace Prize in 1970 for his successes in raising wheat yields across national contexts through his breeding efforts.⁶⁷

However, gaps in the imagined chain of knowledge transfer from research center to farmers’ fields often refused to close. Researchers’ trial demonstrations of new varieties could be carefully orchestrated to show farmers the rewards to be reaped from the adoption of those varieties.⁶⁸ Moving these varieties from successful trials at a central site to cultivation and adoption by farmers in ways that benefitted farmers, especially the poorest and most marginalized farmers, was significantly more difficult.⁶⁹ Critique and condemnation of the Green Revolution—and scientific institutions like the international agricultural research centers and CGIAR that sought to extend it—followed fast on the heels of its initial celebration.⁷⁰ Having reached new heights of international authority and visibility, agricultural scientists found themselves newly vulnerable to assessments of profound limitations to their knowledge.

⁶⁴ Lorek and Curry, “Introduction.” See further contributions on the history of CGIAR in Curry and Lorek, eds., *Agricultural Science as International Development*.

⁶⁵ International Bank for Reconstruction and Development, “New International Research Group Formed.”

⁶⁶ Lorek and Curry, “Introduction”; Thompson and Smith, “Reconsidering ‘Excellence.’”

⁶⁷ Recent histories add important nuance to this story, not least by emphasizing the contributions of Mexican and Indian scientists. See Soto Laveaga, “Beyond Borlaug’s Shadow”; Baranski, “Globalization of Wheat”; Kumar, *History of India’s Green Revolution*.

⁶⁸ Cullather, “Miracles of Modernization.”

⁶⁹ E.g., Stone and Glover, “Disembedding Grain.”

⁷⁰ Curry, “Diversifying Description.”

SOCIAL SCIENTISTS AND FARMERS' EXPERIMENTS

Critiques of industrial agriculture and the research systems allied to it accelerated in the 1970s. These were motivated by rising awareness of the health and environmental consequences of pesticide and fertilizer use and concerns about the ever-increasing power of agribusinesses over food supplies. Where they considered efforts to extend aspects of industrial agriculture through the Green Revolution model, critiques also pointed to social inequalities arising from or exacerbated by encouraging or forcing farmers to rely on expensive inputs and be beholden to international markets. Such critiques occasioned shifts in the agendas of agricultural research. This section examines new conceptualizations of farmers' expertise that took shape amid broader questioning of industrial agriculture and science-led agricultural development. It leads to a consideration of cases where practitioners of agricultural social sciences characterized farmers' field experiences as experiments and their labor and knowledge as agricultural science—attempting to reverse a century-long effort of excluding farmers from this very domain.

Even as agricultural scientists were celebrated in the 1960s for their contributions to eking ever-greater productivity from animals, crops, and soils, their handiwork came under intense scrutiny. Agricultural chemicals, use of which had boomed after World War II, were increasingly associated with harmful effects on the health of humans, wildlife, and ecosystems.⁷¹ Thanks in large part to the work of the scientist and nature writer Rachel Carson in highlighting its effects, the pesticide DDT was among the first targets of the new US Environmental Protection Agency following its creation in 1970. In countries where the food industry had boomed, some consumers grew skeptical of the vast array of shelf-stable processed foods that populated grocery store shelves boasting laboratory-derived preservatives, flavors, colorants, and other additives.⁷² Observers critical of the increasingly global food system also pointed out that the apparent abundance of food generated on farms and in factories had not resolved hunger. Some studies showed that the interventions of the Green Revolution had exacerbated inequality, rather than alleviate poverty, while creating new pollution hazards and biodiversity loss.⁷³

⁷¹ Russell, *War and Nature*; Davis, *Banned*.

⁷² Cobbold, *A Rainbow Palate*; Berenstein, "Flavor Added"; Kirchelle, *Pyrrhic Progress*.

⁷³ Curry, *Endangered Maize*, 134–37.



Figure 10: Emptied pesticide containers adjacent to a farm in Fresno, California, 1972. Photo by Gene Daniels for the US Environmental Protection Agency, Documerica Series. Record Group 412, Series Documerica, NA ID 542507. US National Records and Archives Administration. <https://catalog.archives.gov/id/542507>.

These and other concerns about the benefits of “modern” food and agriculture for both rich and poor were tied up with broader critiques of science and of the alliance among science, state, and industry. The term “agribusiness”—a term that gained traction in the 1960s—signaled the shift from cultivation being controlled by farmers to its being dictated by corporate decisionmakers, who held impressive sway over lawmakers and regulators.⁷⁴ Agricultural scientists were often targeted as allies of agribusiness by those less than enthusiastic about its power. An indictment of agribusiness in the activist magazine *Science for the People* offered this blunt assessment in 1976: “Agricultural research is only indirectly related to feeding people as its orientation is directed, especially in the US, toward profit. Research is carried out by the agricultural supporting industries themselves and by the land-grant colleges whose research priorities are determined by their funding sources: private industry and a government in full support of private industry.”⁷⁵ A *Science for the People* contributor concerned with the trajectory of research in India had much the same to say. “The tragedy is that the takeover of agriculture and agricultural science by industrial interests

⁷⁴ Hamilton, “Agribusiness, the Family Farm.”

⁷⁵ Center for Applied Science, “Agribusiness,” 16. See also Schmalzer, “Agriculture, Ecology, and Food.”

has been achieved with the full support of Indian scientists themselves,” the author, K. R. Bhattacharya, lamented.⁷⁶

The search for alternatives to agribusiness and the knowledge systems that sustained it led critics in different directions. At the household level, growing and producing food at home or seeking alternative products marketed as organic or natural loomed large as strategies for opting out.⁷⁷ Consumer advocates also sought the government’s assistance in providing greater and more effective regulation of food products.⁷⁸ Other critical observers searched for alternative systems that could remake agriculture at larger scales. In the United States, Marxist science activists of the 1970s saw inspiration in China, where they believed control over production decisions lie more resolutely in the hands of those peasants tilling the soil. These US observers celebrated a system they perceived as enabling farmers to participate in agricultural science by “designing and executing research projects.”⁷⁹ They did not yet know of the tremendous human devastation of the Great Famine associated with Mao’s Great Leap Forward and agricultural collectivization from 1959 to 1961.⁸⁰ But they did correctly observe an effort by the Chinese government to bring together “expert research” and “peasant knowledge” in new ways in order to support a transformation in agricultural production that would be both a mass movement and based in scientific experiments.⁸¹

As the example of China suggests, an important source of inspiration for individuals and institutions seeking alternative agricultural models lay in the practices of farmers themselves, especially farmers identified as peasant or Indigenous. The field of agroecology, initially forged as the study of agricultural systems through the disciplinary lens of ecology, by the 1970s increasingly signified the study and practice of more environmentally sound cultivation. In Mexico, the botanist and agronomist Efraím Hernández Xolocotzi was a leader among a new generation of agroecological researchers. Having worked early in his career for the joint Rockefeller Foundation–Mexican government program in Mexico, he grew ever more critical of the approaches espoused by champions of the Green Revolution and agricultural modernization. In the 1970s, together with colleagues, he launched programs in agroecology and ethnobotany from his position at the Universidad Autónoma Chapingo (formerly the Escuela Nacional de Agricultura, the country’s leading institution of agricultural research and training). These focused on the study of “traditional agricultural technology” as

⁷⁶ Bhattacharya, “Soyabeans in India?” 29.

⁷⁷ Case, *Organic Profit*; Barton, *Global History*.

⁷⁸ Boyce, “When Does It Stop Being Peanut Butter?”; Frohlich, *From Label to Table*; Jundt, *Greening the Red, White, and Blue*; Zeide, *Canned*.

⁷⁹ Hansen and Risch, “Food and Agriculture in China,” 40.

⁸⁰ Smil, “China’s Great Famine.”

⁸¹ Schmalzer, *Red Revolution, Green Revolution*.

practiced by Mexico's many Indigenous peoples, advocating for documentation, preservation, and expansion of Indigenous farmers' existing knowledge and tools.⁸²

For adherents in Mexico and beyond, agroecology encompassed both the study of Indigenous and local agricultural practices and using this research to advocate that these practices be valued, sustained, and relied on as a model for future development—instead of the science and technologies pushed on farmers by states and aid programs.⁸³ The practices identified and in many cases newly valorized by agroecologists encompassed seed and crop preferences, water management techniques, insect and disease control measures, and cultivation strategies such as shifting or swidden agriculture.

Also allied to this view were many social scientists who set their sights on understanding agriculture and development, whether as geographers, sociologists, or anthropologists. By the 1970s and early 1980s these experts more frequently started from the premise that farmers possessed valuable knowledge and skills and sought routes to integrate these into research protocols and institutions. But first they had to make a case for their relevance of their own expertise. Except for economics, social sciences had typically been marginalized or entirely neglected within national and international agricultural research systems, which focused on the natural sciences precisely because these seemed to avoid thorny social, political, and economic questions. Critiques of the Green Revolution and other development interventions highlighted problems with this limited expertise. Understanding why farmers opted against improved seeds, how approaches advocated by experts were implemented, or what local problems prevented or distracted farmers from pursuing the modernization encouraged by experts required on-farm analyses.⁸⁴

Responding in part to this concern, the Rockefeller Foundation established fellowships for social scientists at the international agricultural research centers affiliated with CGIAR in 1974. Those researchers' presence was associated in turn with a flurry of new "farmer-centered" research programs, studies that sought to incorporate farmers' knowledge and views into research strategies as well as into the development of agricultural interventions.⁸⁵ For example, a farmer-centered approach to breeding and disseminating new crop varieties might solicit farmers' insights into the traits desired in a particular crop plant through surveys, ask for their input into selective breeding choices at the experiment station, or train farmers to carry out aspects of the breeding program on their own farm. In these

⁸² Gliessman, "Agroecology"; Astier et al., "Back to the Roots."

⁸³ Altieri, *Agroecology*. See also Hecht, "Evolution of Agroecological Thought."

⁸⁴ Curry, *Endangered Maize*, 207–8.

⁸⁵ Curry, *Endangered Maize*, 207–8.

“participatory breeding programs” and similarly designed endeavors, farmers were imagined by scientists as capable co-experimenters.⁸⁶



Figure 11: Women participants in a breeding program run by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), undated. Photo: by C. Wangari for ICRISAT. CC BY-NC 2.0. <https://www.flickr.com/photos/icrisat/7176443117/in/album-72157630100632832/>.

Other social scientists pressed for a more encompassing re-imagination of the relationship between farmer and scientist. The London-trained geographer Paul Richards numbered among a group of scholars who insisted on farmers as capable experimenters in their own right, independent of professional scientists’ interventions. Reviewing examples of West African farmers’ management of rice varieties and grasshopper pests, he observed that “farmers apply their own notions of ‘research and development’ (R&D) in an entirely deliberate and self-aware manner.”⁸⁷ His observations of farmers acquiring knowledge through experiments led Richards to advocate for a model of agricultural research in which “formal-sector” researchers address only questions that farmers themselves could not answer and to suggest that agricultural agents play a role in spreading the best practices learned by farmers. Observing that West African countries “might pursue an agricultural revolution largely through mobilization of indigenous skills and resources,” he recognized the resulting “profound implications for the training of agricultural professionals.” The

⁸⁶ See examples in Eyzaguirre and Iwanaga, *Participatory Plant Breeding*; Moock and Rhoades, *Diversity*.

⁸⁷ Richards, *Indigenous Agricultural Revolution*, 149.

“agricultural expert” would no longer dictate “best” practices to farmers but instead facilitate farmers’ own experiments and knowledge acquisition.⁸⁸

Historians Christophe Bonneuil and Helen Tilley have noted the significant debt that studies such as those conducted by Richards and like-minded social scientists—committed to deep knowledge of local cultures and ecologies and advocates of grassroots solutions—owed to top-down colonial impositions. As Bonneuil points out, several social scientists who achieved prominence in the turn to farmer-centered research initially gained access to farmers through settlement schemes. Thanks to prior decades of colonial interventions, such farmers were more “amenable to data extraction” in the form of surveys, interviews, observation, and other intrusive fieldwork by foreigners.⁸⁹ Tilley, pushing further, finds the intellectual antecedents for critiques of top-down colonial projects (and their development-era successors) in research conducted by colonial agents in the 1930s and 40s.⁹⁰

The arguments advanced by Bonneuil and Tilley temper assessments of the radical nature of the insights achieved through the more robust integration of social scientists into the domain of agricultural science in the 1970s and thereafter. So, too, does the longer history charted in this essay, that these social scientists ostensibly just returned some agricultural science to the spaces from which this enterprise initially launched: farmers’ fields.

CONCLUSION

This brief history of agricultural science, sensitive to shifts in who historically has counted as an authoritative knower and experimenter, produces a curious narrative. It begins, as so many accounts have, with the ascent and institutionalization of agricultural sciences based in the natural sciences. However, by including the expansion of the institutions of agricultural science to encompass social sciences such as rural geography and anthropology, this history must also then reckon with a critique of the exclusionary concept of “agricultural science” on which it was initially premised.

A geographer like Paul Richards would presumably insist that a history of agricultural science is as long, or nearly so, as the thousands of years of human agricultural history indicated in archaeological record. Others would observe, rightly, that this long history would have to attend to humans’ knowledge of forest resources, water management techniques, controlled burning, household organization, and many other factors that contribute to agricultural production beyond the care of animals and cultivation of plants. Although this article cannot

⁸⁸ Richards, *Indigenous Agricultural Revolution*, 155. See also Richards, “Experimenting Farmers.” A useful overview of relevant literature is Hansson, “Farmers’ Experiments.”

⁸⁹ Bonneuil, “Development as Experiment,” 279–80.

⁹⁰ Tilley, *Africa as a Living Laboratory*, ch. 3.

hope to respond to such a demand, it does provide insight into where it might originate and the motivations that lie behind it.

Acknowledgements: I am grateful to Samantha Lieberman for assistance with the research for this article.

BIBLIOGRAPHY

- Altieri, Miguel A. *Agroecology: The Science of Sustainable Agriculture*. 2nd ed. Boca Raton: CRC Press, 2018.
- Ambrosoli, Mauro. *The Wild and the Sown: Botany and Agriculture in Western Europe, 1350–1850*. Translated by Mary McCann Salvatorelli. Cambridge: Cambridge University Press, 1997.
- Anderson, J. L. "The Growing Power of Agricultural Science." In *The Oxford Handbook of Agricultural History*, edited by Jeannie Whayne, 177–95. Oxford: Oxford University Press, 2024.
- Astier, Marta, Jorge Quetzal Argueta, Quetzalcóatl Orozco-Ramírez, et al. "Back to the Roots: Understanding Current Agroecological Movement, Science, and Practice in Mexico." *Agroecology and Sustainable Food Systems* 41, nos. 3–4 (2017): 329–48.
- Baber, Zaheer. "The Plants of Empire: Botanic Gardens, Colonial Power and Botanical Knowledge." *Journal of Contemporary Asia* 46, no. 4 (2016): 659–79.
- Baranski, Marci. *The Globalization of Wheat: A Critical History of the Green Revolution*. Pittsburgh: University of Pittsburgh Press, 2022.
- Barton, Gregory A. *The Global History of Organic Farming*. Oxford: Oxford University Press, 2018.
- Batsaki, Yota, Sarah Burke Calahan, and Anatole Tchikine. *The Botany of Empire in the Long Eighteenth Century*. Washington, DC: Dumbarton Oaks, 2017.
- Berenstein, Nadia. "Flavor Added: The Sciences of Flavor and the Industrialization of Taste in America." PhD diss., University of Pennsylvania, 2018.
- Bhattacharya, K.R. "Soyabeans in India?" *Science for the People* 7, no. 1 (January 1975): 27–29.
- Bonneuil, Christophe. "Development as Experiment: Science and State Building in Late Colonial and Postcolonial Africa, 1930–1970." *Osiris* 15 (2000): 258–81.
- Bonneuil, Christophe. "Penetrating the Natives: Peanut Breeding, Peasants and the Colonial State in Senegal (1900–1950)." *Science, Technology & Society* 4, no. 2 (1999): 273–302.
- Boyce, Angie M. "'When Does It Stop Being Peanut Butter?': FDA Food Standards of Identity, Ruth Desmond, and the Shifting Politics of Consumer Activism, 1960s–1970s." *Technology and Culture* 57, no. 1 (2016): 54–79.
- Bray, Francesca. "Science, Technique, Technology: Passages between Matter and Knowledge in Imperial Chinese Agriculture." *British Journal for the History of Science* 41, no. 3 (2008): 319–44.
- Bray, Francesca, Barbara Hahn, John Bosco Lourdasamy and Tiago Saraiva. *Moving Crops and the Scales of History*. New Haven: Yale University Press, 2023.

Brockway, Lucile H. *Science and Colonial Expansion: The Role of the British Royal Botanic Gardens*. New York and London: Academic Press, 1979.

Byerlee, Derek, and John K. Lynam. "The Development of the International Center Model for Agricultural Research: A Prehistory of the CGIAR." *World Development* 135 (2020): 105080.

Case, Andrew N. *The Organic Profit: Rodale and the Making of Marketplace Environmentalism*. Seattle: University of Washington Press, 2018.

Center for Applied Science. "Agribusiness: Feeding Profit Rather than People." *Science for the People* 8, no. 4 (March 1976): 15–17.

Chambers, J. D., and G. E. Mingay. *The Agricultural Revolution: 1750–1880*. New York: Schocken Books, 1966.

Chu, Chiali. "Harvesting Diversity: Taiwan, Southeast Asia, and the Transformation of the Green Revolution, 1950–2000." PhD thesis, University of Cambridge, 2024.

Cobbold, Carolyn. *A Rainbow Palate: How Chemical Dyes Changed the West's Relationship with Food*. Chicago: University of Chicago Press, 2020.

Collingham, Lizzie. *The Taste of War: World War II and the Battle for Food*. New York: Penguin, 2011.

Conway, Richard. "Rural Indians and Technological Innovation, From the Chinampas of Xochimilco and Beyond." In *Oxford Research Encyclopedia of Latin American History*. Oxford: Oxford University Press, 2018.

Cullather, Nick. *The Hungry World: America's Cold War Battle against Poverty in Asia*. Cambridge, MA: Harvard University Press, 2010.

Cullather, Nick. "Miracles of Modernization: The Green Revolution and the Apotheosis of Technology." *Diplomatic History* 28, no. 29 (2004): 227–54.

Curry, Helen Anne. "Diversifying Description: Sweet Potato Science and International Agricultural Research after the Green Revolution." *Agricultural History* 97, no. 3 (2023): 414–47.

Curry, Helen Anne. *Endangered Maize: Industrial Agriculture and the Crisis of Extinction*. Oakland: University of California Press, 2021.

Curry, Helen Anne, and Timothy W. Lorek. *Agricultural Science as International Development: Historical Perspectives on the CGIAR Era*. Cambridge: Cambridge University Press, 2024.

Danbom, David B. "Agricultural Experiment Station and Professionalization: Scientists' Goals for Agriculture." *Agricultural History* 60, no. 2 (1986): 246–55.

Davis, Frederick Rowe. *Banned: A History of Pesticides and the Science of Toxicology*. New Haven: Yale University Press, 2014.

Decker, Michael. "Plants and Progress: Rethinking the Islamic Agricultural Revolution." *Journal of World History* 20, no. 2 (2009): 187–206.

Diser, Lyvia. "Laboratory versus Farm: The Triumph of Laboratory Science in Belgian Agriculture at the End of the Nineteenth Century." *Agricultural History* 86, no. 1 (2012): 31–54.

Drayton, Richard. *Nature's Government: Science, Imperial Britain, and the "Improvement" of the World*. New Haven: Yale University Press, 2000.

Easterby-Smith, Sarah. *Cultivating Commerce: Cultures of Botany in Britain and France, 1760–1815*. Cambridge: University of Cambridge Press, 2018.

Elina, Olga. "Planting Seeds for the Revolution: The Rise of Russian Agricultural Science, 1860–1920." *Science in Context* 15, no. 2 (2002): 209–37.

Eyzaguirre, P., and M. Iwanaga. *Participatory Plant Breeding*. Rome: Bioversity, 1996.

Fagnani, Martino Lorenzo. *The Development of Agricultural Science in Northern Italy in the Late Eighteenth and Early Nineteenth Century*. Cham, Switzerland: Palgrave Macmillan, 2023.

Fagnani, Martino Lorenzo. "Studying 'Useful Plants' from Maria Theresa to Napoleon: Continuity and Invisibility in Agricultural Science, Northern Italy, the Late Eighteenth to Early Nineteenth Century." *History of Science* 59, no. 4 (2021): 373–406.

Ferleger, Louis A. "European Agricultural Development and Institutional Change: German Experiment Stations, 1870–1920." *Journal of the Historical Society* 5 (2005): 417–28.

Ferleger, Lou. "Uplifting American Agriculture: Experiment Station Scientists and the Office of Experiment Stations in the Early Years after the Hatch Act." *Agricultural History* 64, no. 2 (1990): 5–23. <http://www.jstor.org/stable/3743792>.

Finlay, Mark. "The German Agricultural Experiment Stations and the Beginnings of American Agricultural Research." *Agricultural History* 62, no. 2 (1988): 41–50.

Finlay, Mark. "Science, Practice and Politics: German Agricultural Experiment Stations in the Nineteenth Century." PhD diss., Iowa State University, 1992.

Fitzgerald, Deborah. *Every Farm a Factory: The Industrial Ideal in American Agriculture*. New Haven: Yale University Press, 2003.

Frohlich, Xaq. *From Label to Table: Regulating Food in America in the Information Age*. Oakland: University of California Press, 2023.

Gliessman, Steve. "Agroecology: Growing the Roots of Resistance." *Agroecology and Sustainable Food Systems* 37, no. 1 (2013): 19–33.

González, Roberto J. *Zapotec Science: Farming and Food in the Northern Sierra of Oaxaca*. Austin: University of Texas Press, 2001.

Guldi, Jo. *The Long Land War: The Global Struggle for Occupancy Rights*. New Haven: Yale University Press, 2022.

Hamilton, Shane. "Agribusiness, the Family Farm, and the Politics of Technological Determinism in the Post-World War II United States." *Technology and Culture* 55, no. 3 (2014): 560–90.

Hansen, Michael K., and Stephen J. Risch. "Food and Agriculture in China, Part I." *Science for the People* 11, no. 3 (May-June 1979): 39–45.

Hansson, Sven Ove. "Farmers' Experiments and Scientific Methodology." *European Journal for Philosophy of Science* 9, Article number 32 (2019). <https://doi.org/10.1007/s13194-019-0255-7>.

Harwood, Jonathan. "Comments on Experimentation in Twentieth-Century Agricultural Science." *History and Philosophy of the Life Sciences* 37, no. 3 (2015): 326–30.

Harwood, Jonathan. *Europe's Green Revolution and Others Since: The Rise and Fall of Peasant-Friendly Plant Breeding*. London: Routledge Taylor & Francis Group, 2011.

Harwood, Jonathan. *Technology's Dilemma: Agricultural Colleges between Science and Practice in Germany, 1860–1934*. New York: Peter Lang, 2005.

Harwood, Jonathan. "Was the Green Revolution Intended to Maximise Food Production?" *International Journal of Agricultural Sustainability* 17, no. 4 (2019): 312–25.

Hecht, Susanna B. "Evolution of Agroecological Thought." In *Agroecology: The Science of Sustainable Agriculture*, edited by Miguel A. Altieri, 1–20. 2nd ed. Boca Raton: CRC, 2018.

Hodge, Joseph M. "British Colonial Expertise, Post-Colonial Careerism and the Early History of International Development." *Journal of Modern European History* 8, no. 1 (2010): 2–46.

Hodge, Joseph M. "Science, Development, and Empire: The Colonial Advisory Council on Agriculture and Animal Health, 1929–43." *Journal of Imperial and Commonwealth History* 30, no. 1 (2002): 1–26.

Hodge, Joseph M. *Triumph of the Expert: Agrarian Doctrines of Development and the Legacies of British Colonialism*. Athens: Ohio University Press, 2007.

International Bank for Reconstruction and Development. "New International Research Group Formed." Press release, May 20, 1971. <https://hdl.handle.net/10947/259>.

Jarosz, Lucy. "The Political Economy of Global Governance and the World Food Crisis: The Case of the FAO." *Third World Quarterly* 20, no. 1 (1999): 223–38.

Jones, Peter. *Agricultural Enlightenment: Knowledge, Technology, and Nature, 1750–1840*. Oxford: Oxford University Press, 2016.

Jundt, Thomas. *Greening the Red, White, and Blue: The Bomb, Big Business, and Consumer Resistance in Postwar America*. Oxford: Oxford University Press, 2014.

Kirchhelle, Claas. *Pyrrhic Progress: The History of Antibiotics in Anglo-American Food Production*. New Brunswick, NJ: Rutgers University Press, 2020.

Kumar, Prakash. *A History of India's Green Revolution: Reign of Technocracy*. Cambridge: Cambridge University Press, 2025.

Kumar, Prakash. "Modalities of Modernization: American Technic in Colonial and Postcolonial India." In *How Knowledge Moves: Writing the Transnational History of Science and Technology*, edited by John Krige, 128–55. Chicago: University of Chicago Press, 2019.

Kumar, Prakash. "Plantation Science: Improving Natural Indigo in Colonial India, 1860–1913." *The British Journal for the History of Science* 40, no. 4 (2007): 537–65.

Kumar, Prakash. "US–India Entanglements and the Founding of ICRISAT in India." In *Agricultural Science as International Development: Historical Perspectives on the CGIAR Era*, edited by Helen Anne Curry and Timothy Lorek, 44–62. Cambridge: Cambridge University Press, 2024.

Lavelle, Peter. "Placing the Science of Agriculture in Twentieth-Century China." *Isis* 113, no. 4 (2022): 816–28.

Lorek, Timothy W. *Making the Green Revolution: Agriculture and Conflict in Colombia*. Chapel Hill: University of North Carolina Press, 2024.

Lorek, Timothy W., and Helen Anne Curry. "Introduction: Past, Present, and Future Histories of CGIAR." In *Agricultural Science as International Development: Historical Perspectives on the CGIAR Era*, edited by Helen Anne Curry and Timothy W. Lorek, 1–14. Cambridge: Cambridge University Press, 2024.

Maat, Harro. "The History and Future of Agricultural Experiments." *NJAS Wageningen Journal of the Life Sciences* 57, no. 3–4 (2011): 187–95.

Maat, Harro. *Science Cultivating Practice: A History of Agricultural Science in the Netherlands and Its Colonies, 1863–1986*. Wageningen: Wageningen University, 2001.

Marcus, Alan I. "The Historians' Corner: American Agricultural Science." In *A Companion to American Agricultural History*, edited by R. Douglas Hurt, 147–60. Hoboken, NJ: John Wiley & Sons, 2022.

McCook, Stuart George. *States of Nature: Science, Agriculture, and Environment in the Spanish Caribbean, 1760–1940*. Austin: University of Texas Press, 2002.

McDonald, Bryan. *Food Power: The Rise and Fall of the Postwar American Food System*. Oxford: Oxford University Press, 2017.

Moock, Joyce Lewinger, and Robert E. Rhoades, eds. *Diversity, Farmer Knowledge, and Sustainability*. Ithaca, NY: Cornell University Press, 1992.

Nehring, Ryan. "The Brazilian Green Revolution." *Political Geography* 95 (2022): 102574.

Nehring, Ryan. "The Technopolitics of Agronomic Knowledge and Tropical(izing) Vegetables in Brazil." *Environmental Science & Policy* 162 (2024): 103911.

Nehring, Ryan. "Yield of Dreams: Marching West and the Politics of Scientific Knowledge in the Brazilian Agricultural Research Corporation (Embrapa)." *Geoforum* 77 (2016): 206–17.

Olsson, Tore C. *Agrarian Crossings: Reformers and the Remaking of the US and Mexican Countryside*. Princeton, NJ: Princeton University Press, 2017.

Osorio, Alejandra. "Why *Chuño* Matters: Rethinking the History of Technology in Latin America." *Technology and Culture* 63, no. 3 (2022): 808–29.

Patel, Raj. "The Long Green Revolution." *The Journal of Peasant Studies* 40, no. 1 (2012): 1–63.

Pawley, Emily. "Accounting with the Fields: Chemistry and Value in Nutrient in American Agricultural Improvement, 1835–1860." *Science as Culture* 19, no. 4 (2010): 461–82.

Pawley, Emily. *The Nature of the Future: Agriculture, Science, and Capitalism in the Antebellum North*. Chicago: University of Chicago Press, 2020.

Perkins, John H. *Geopolitics and the Green Revolution: Wheat, Genes, and the Cold War*. New York: Oxford University Press, 1997.

Phillips, Denise. "Socrates on the Farm: Agricultural Improvement and Rural Knowledge in Eighteenth-Century Germany and Switzerland." *Berichte zur Wissenschaftsgeschichte* 44, no. 2 (2021): 109–255.

Richards, Paul. "Experimenting Farmers and Agricultural Research." In *Rural Households in Emerging Societies*, edited by Margaret Haswell and Diana Hunt, 11–21. London: Routledge, 1991.

Richards, Paul. *Indigenous Agricultural Revolution: Ecology and Food Production in West Africa*. London: Unwin Hyman, 1985.

Rosenberg, Charles E. *No Other Gods: On Science and American Social Thought*. Revised and expanded ed. Baltimore: Johns Hopkins University Press, 1997.

Rossiter, Margaret W. *The Emergence of Agricultural Science: Justus Liebig and the Americans*. New Haven: Yale University Press, 1975.

Russell, Edmund. *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring*. Cambridge: Cambridge University Press, 2001.

Saha, Madhumita. "Food for Soil, Food for People: Research on Food Crops, Fertilizers, and the Making of 'Modern' Indian Agriculture." *Technology and Culture* 54, no. 2 (2013): 289–316.

Saraiva, Tiago. *Fascist Pigs: Technoscientific Organisms and the History of Fascism*. Cambridge, MA: MIT Press, 2016.

Schiebinger, Londa, and Claudia Swan. *Colonial Botany: Science, Commerce, and Politics in the Early Modern World*. Philadelphia: University of Pennsylvania Press, 2007.

Schmalzer, Sigrid. "Agriculture, Ecology, and Food." In *Science for the People: Documents from America's Movement of Radical Scientists*, edited by Sigrid Schmalzer, Daniel S. Chard, and Alyssa Botelho, 135–53. Amherst: University of Massachusetts Press, 2018.

Schmalzer, Sigrid. *Red Revolution, Green Revolution: Scientific Farming in Socialist China*. Chicago: University of Chicago Press, 2015.

Scott, James C. *Against the Grain: A Deep History of the Earliest States*. New Haven: Yale University Press, 2017.

Shopov, Aleksandar. "Flower Breeding in Early Modern Istanbul: A Science of Seeds." *Isis* 113, no. 2 (2022): 588–96.

Smil, Vaclav. "China's Great Famine: 40 years Later." *BMJ (Clinical research edition)* 31, no. 7225 (1999): 1619–21.

Smith, Jenny Leigh. *Works in Progress: Plans and Realities on Soviet Farms, 1930–1963*. New Haven: Yale University Press, 2014.

Soto Laveaga, Gabriela. "Beyond Borlaug's Shadow: Octavio Paz, Indian Farmers, and the Challenge of Narrating the Green Revolution." *Agricultural History* 95, no. 4 (2021): 576–608.

Soto Laveaga, Gabriela. "The Socialist Origins of the Green Revolution: Pandurang Khankhoje and Domestic Technical Assistance." *History and Technology* 36, nos. 3–4 (2020): 337–59.

Staples, Amy L. S. *The Birth of Development: How the World Bank, Food and Agriculture Organization, and World Health Organization Changed the World*. Kent: Kent State University Press, 2006.

Stone, Glenn David, and Dominic Glover. "Disembedding Grain: Golden Rice, the Green Revolution, and Heirloom Seeds in the Philippines." *Agriculture and Human Values* 34 (2017): 87–102.

Stunden Bower, Shannon. "Women's Garden Work, Agricultural Rehabilitation, and Gendered Knowledge from Below on the Canadian Prairies, 1930–46." *The Canadian Historical Review* 105, no. 2 (2024): 276–300.

Thompson, Rebekah, and James Smith. "Reconsidering 'Excellence': Natural and Social Science Approaches to Livestock Research at IRLI." In *Agricultural Science as International Development: Historical Perspectives on the CGIAR Era*, edited by Helen Anne Curry and Timothy W. Lorek, 158–80. Cambridge: Cambridge University Press, 2024.

Tilley, Helen. *Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870–1950*. Chicago: University of Chicago Press, 2011.

Van der Schoor, Wim. "Pure Science and Colonial Agriculture: The Case of the Java Sugar Experimental Stations (1885–1940)." In *Nature et environnement*, edited by Yvon Chatelin and Christophe Bonneuil, 13–20. Paris: Orstom Éditions, 1995.

Wang, Kuan-Chi, and Daniel Buck. "Relocating Agrarian Development in Asia: Food Regimes, R&D Programs, and the Long Twentieth Century." *The Journal of Peasant Studies* 51, no. 1 (2024): 212–36.

Wezel, A., S. Bellon, T. Doré, C. Francis, D. Vallod, and C. David. "Agroecology as a Science, a Movement and a Practice. A Review." *Agronomy for Sustainable Development* 29 (2009): 503–15.

Wilmot, Sarah. "'The Business of Improvement': Agriculture and Scientific Culture in Britain, c. 1700 – c. 1870." *Historical Geography Research Series*, no. 24 (November 1990).

Zeide, Anna. *Canned: The Rise and Fall of Consumer Confidence in the American Food Industry*. Oakland: University of California Press, 2018.