

Geneticists on the farm: agriculture and the all-English loaf

Berris Charnley

Bread – daily and sacramental – is an article of spiritual life in many of the world’s cultures. With circuses (*panem et circenses*), and on its own, bread has political meaning. Let them eat brioche, bread riots, corn laws: bread and its constituents have been at the top table for much of Western political history.¹ And, of course, for much of the planet, for much of history, bread has been a key nutritional staple – staff of life. Bread’s ability to bear these metaphorical and literal meanings stems, at least partly, from the great variability of this near-ubiquitous foodstuff. Bread can be brown or white, baked or steamed, homemade or shop bought, artisanal or industrial, imported or home grown. Such diversity of meaning and material makes attempts to control or change bread ideal case studies of governance. This chapter addresses attempts by the first geneticists to govern agricultural practices around bread making.

In Britain at the turn of the twentieth century, white and industrially produced bread was becoming more pervasive.² However, if this was a period marked by the arrival of modern bread, many agricultural improvers were still preoccupied with pre-modern mercantilist worries about home production.³ Britain was importing the majority of its bread-making wheat while traditional arable farming areas were abandoned by farmers unable to compete with imports on quality or price. Assuming that producing more home-grown bread-making flour would be good for British farmers and millers, the first geneticists took up the challenge of producing new varieties that would increase home-grown wheat production, secure Britain’s white bread supply and stabilise its arable agriculture.

When genetics arrived in Britain in the first years of the twentieth

century the discipline was developed in the hands of a group of scientists who saw themselves as bringing new precision, accuracy and control to the old traditions embodied in the art of plant breeding.⁴ As a freshly minted discipline, genetics had no traditions to observe; it was claimed to be a modern science from the outset.⁵ There is a healthy debate in the history of genetics over how the discipline was governed and, furthermore, over how genetics did or did not change plant breeding.⁶ However, the question this latter debate implies, as to whether geneticists – through the release of new plant varieties – changed agricultural practices, is the subject addressed here in detail.

One of the first geneticists, Rowland Biffen, Chair of Agricultural Botany at Cambridge University, was vociferous in his attempts to improve agriculture. Consider the following exchange between Biffen and Mr Patterson, at the London Farmers' Club:

Mr. Patterson made the point that it pays one to grow what I may call indifferent quality wheats merely for the purpose of chicken food. Do not for a moment go away with the impression that I want to teach you how to farm. I know nothing about farming, but I am going to make the suggestion that [high quality] Yeoman wheat may be as good for chickens, and therefore it might be worth trying the double event. If the chicken food trade does drop, then the human subject might be worth feeding.⁷

Despite Biffen's feigned reticence, much of the paper he delivered that evening – which had sparked the exchange between himself and Patterson – was devoted to persuading farmers that they should grow his variety, Yeoman, to produce human-feeding bread-making flour.

However, as the evidence presented in this chapter demonstrates, Biffen's varieties were popular with farmers and agriculturally important for reasons that Biffen did not principally intend. Mendelians – early geneticists who drew inspiration from the work of Gregor Mendel – who sought to develop agriculture in productive new directions were mostly concerned with improving quality. But, for their part, farmers adopted Mendelian varieties into two clear types of farming, neither of which prioritised quality. Before the First World War, farmers fitted Mendelian varieties into a pattern of farming that reduced expenditure on inputs, while aiming for lower-value outputs: chicken feed or thatching straw,

for instance.⁸ After the war, when farms were larger and farmers relatively richer, Mendelian varieties were part of an increasingly intensive style of farming in which farmers increased expenditure so as to improve yields.

The chapter begins with an overview of Biffen's plans to tailor varieties for the British wheat industry. The popularity of Biffen's varieties is then explored, along with their use, in a pair of sections which analyse the question of Mendelian wheat's role in the field. The focus throughout the chapter is on commercial wheat farmers in the south-east of England, farmers such as McFarlane Grieve or Fred Hiam, who gifted whole farms to Biffen's home Department of Agriculture at Cambridge University and the allied National Institute of Agricultural Botany at which Biffen was Chief Scientific Advisor. If this restriction of view seems unduly narrow, it is worth remembering that wheat was the principal crop of the period, and the south-east of England the centre of wheat production in the country. For many would-be agricultural improvers, the area was the faltering heart of Britain's failing agricultural industry.⁹

Mendelian strategies for agricultural development

Biffen believed that new plant varieties were the best way to combat problems faced by farmers as a result of the depression in wheat farming in the 1880s. As Biffen put it in an article written for *The Times* on the eve of the First World War, the best way forward was to 'leave it to the plant-breeders to add to the value of the crop per acre by improving the varieties now grown'.¹⁰ Biffen worked on several strategies for adding value to crops. The following discussion concentrates on the three strategies which informed the creation of his two most popular varieties, Little Joss and Yeoman.¹¹

When Biffen began plant breeding, in the years around 1901, he was convinced that the wheat plant had reached its yielding limit. Wheat yields in Britain were already three times higher than those in the New World. Most British farmers produced thirty bushels per acre, although occasionally, with good land and some skill or luck they might harvest sixty to eighty bushels from an acre. In America and Australia, ten to twenty bushels per acre was considered a good crop.¹² With this in mind, Biffen intended his first variety, Little Joss, to increase yields indirectly. Little Joss was released and recommended to farmers in the years around 1910 as a variety that was

resistant to yellow rust, a pathogen that attacked wheat. As Biffen sent out parcels of seed to local farmers Little Joss's fame spread and the variety's distribution was widely noted in the popular press.¹³

Biffen became interested in yellow rust early in his career. When he had studied botany under Henry Marshall Ward, mycology – the study of fungi – had formed the basis of the first papers he published.¹⁴ Biffen's initial interest in the disease was academic; however, he quickly began promoting the economic benefits of resistance to yellow rust. Unfortunately, yellow rust was only one of the many pathogens that could attack wheat. Farmers also had to contend with bunt (or smut), stem rust and mildew; they considered yellow rust relatively unimportant in comparison. Despite farmers' indifference to yellow rust resistance, Biffen continued believing that disease resistance was an important way of improving wheat yields.¹⁵ When he travelled to Kenya in the late 1920s as a special adviser, breeding new disease-resistant varieties of wheat was the strategy he recommended to the colonial government.¹⁶

In 1903, speaking to the Cambridge Philosophical Society, Biffen recalled beginning his wheat-breeding experiments in the summer of 1901; not just to test the wider applicability of 'Mendel's laws' of heredity – which Biffen took to be the theoretical basis of the new discipline – but also 'with the object of raising improved varieties from the point of view of the farmer and the miller'.¹⁷ Improving the bread-making quality of British wheat was Biffen's most direct attempt to address arable farming's problems.

At the turn of the century Britain imported nearly 80% of the wheat used in the country.¹⁸ British wheat lacked 'strength' – the ability to produce a fluffy and voluminous 'well piled [white] loaf'.¹⁹ Imported wheat was not only stronger, it was also cheaper to produce on the fertile prairies of the New World; imported wheat therefore commanded higher prices in a market which had generally fallen. Biffen argued that British farmers should look to improve the strength of their crop. The way to do this, Biffen suggested, was to breed stronger wheat varieties. The hope was to revive the industry by producing an 'All-English' loaf. Yeoman was Biffen's solution to this problem: a British wheat variety of similar strength to imported wheat. The Board of Agriculture's first announcement of the variety made clear that Yeoman 'is sufficiently strong to produce a good quality loaf without the addition of imported flour'.²⁰

In 1913 Biffen's supporters had already begun to claim early success for his strength-focused breeding programme. Walter Runciman, President of the Board of Agriculture at the time, laid out the promise of Biffen's strong wheats to Parliament while arguing for increased funding for Biffen's plant breeding: 'At Cambridge, already Professor Biffen has proved he can grow wheat in large quantities of the [quality] of Canadian wheat and the fecundity of British wheat, and that cannot but be of great monetary advantage to the farmers of this country.'²¹ After the war the campaign drew further support and several newspapers, including the *Daily Mail* took up the All-English cause:

When the home-grown loaf is made again in this country on a large and useful scale (as hopeful agriculturalists believe it will be made) it will be due in a great measure to the work of Professor R.H. Biffen head of the School of Agricultural Botany at Cambridge [*sic*].²²

The All-English campaign reached a peak in 1923 with the release of the Linlithgow Committee's interim report. The Committee whole-heartedly endorsed Yeoman and the All-English solution. The report also, however, contained a hint of the problems associated with this course of action, suggesting that it was not inevitable that strong wheat would be of 'great monetary advantage' to farmers as Runciman claimed. Some farmers, the Committee's report noted, 'inclined to blame the trade for much of the prejudice that exists on the part of the consuming public in favour of white highly aerated bread'.²³ These farmers 'assert[ed] that bakers are interested in encouraging the public taste in this direction'.²⁴ The farmers' suspicion was that this sort of flour was better suited for recently introduced milling processes, using heavy rollers, but did little for them.²⁵ Ominously, for concerned farmers, the Committee concluded that, 'the creation of an articulate demand [for white bread] is essential' for the development of arable farming.²⁶

Despite Biffen's initial belief that the wheat plant had reached its yielding limit, he eventually did come to recommend more intensive cultivation. As cheaper artificial fertiliser became available from the Haber-Bosch process for ammonia production, farmers increasingly used fertiliser, hoping to increase yields.²⁷ However, farmers who could afford this new source of nutrients ran into a significant problem. As the heads of their wheat plants grew bigger they were also more likely to fall over, dragging the plant into the ground and

becoming 'laid'.²⁸ A laid crop could be ruinous to a farmer; it made harvesting much more difficult, especially as it meant mechanical harvesters could not be used; these would simply grind the crop further into the ground. Biffen's solution was to breed new varieties with a shorter, thicker stem. As he put it to another post-war reconstruction meeting, the Selborne Committee, 'Stiffer straws capable of carrying heavier crops ... will have to be provided before the most can be made of intensive cultivation.'²⁹

Biffen had already made some moves in this direction in 1910 with a variety called Burgoyne's Fife. By Biffen's own reckoning this was a 'gentleman's wheat'; it needed care, attention and intense fertilising to reach its full yielding capability.³⁰ Burgoyne's Fife swiftly disappeared, Biffen believed, because farmers in 1910 were unwilling to spend money on fertiliser and feared the losses that might ensue if a crop became laid. Although Biffen remained sceptical as to the point of growing more low-quality wheat, intensification was a secondary aim of Yeoman, which had a much shorter straw than Little Joss.³¹

To some extent Biffen ran these three strategies together, the aim being to build up an ideal wheat variety with disease resistance, strength and a higher yield. Biffen's allies in government promoted this bold vision. Rowland Prothero, Runciman's successor as President of the Board of Agriculture, while speaking to Parliament, and also arguing for more funding for Biffen's work, explicitly linked the strategies together. He began by introducing Biffen's work:

It has been discovered that you can create a new variety of a plant by [combining] characteristics of other varieties of the plant. The result of this is most remarkable. Instead of having to wait for the chance discoveries of nature we can deliberately sit down and manufacture the kind of plant that we want.³²

Prothero went on to describe the latest of Biffen's new varieties:

He has now produced a wheat which produces a high quality of straw – a fine, stiff, upstanding straw – and a high quality of yield of grain, so much so that without pushing it will produce forty-two bushels to the acre, and by pushing up to seventy-two bushels to the acre. It also possesses a very high quality of disease resistance, and it combines with these qualities the quality of strength which is so highly valued by both millers and bakers, and which is recognised in increased prices.³³

The popularity of Mendelian varieties

These sorts of projections of the possibilities of Mendelian varieties prompt two related questions. How popular were Biffen's varieties? And how were they used? Little Joss and Yeoman were a staple feature at the Royal Horticultural and Agricultural Societies, the British Association for the Advancement of Science, *Nature* and *The Times*. When Biffen was awarded the Royal Society's Darwin Medal in 1920, *Nature* reported: 'Two of [Biffen's] new wheats ... are among the most popular in the country, and together account for something like a third, or even a half of the wheat crop of England.'³⁴ But how popular were Biffen's varieties with farmers? There is very little data available with which to answer this question, as crop returns from the period did not differentiate between varieties. However, figures from seed testing and the awards some farmers gave to Biffen point to a broad base of popularity – especially with farmers in south-eastern England – which really did live up to the claims made in more rarefied forums.

At the turn of the century there were hundreds of varieties of wheat in Britain. In 1921 the National Institute of Agricultural Botany held at least 125 in its observation plots.³⁵ Figures released in 1923 by the Official Seed Testing Station, housed at this point in the buildings of the National Institute of Agricultural Botany, indicate that out of these many varieties eight were grown extensively. Batches of seed sent to the station were tested for identity (as well as purity and germination), so it is possible to tabulate the amount of each variety tested. Although these figures reflect only the popularity of Biffen's varieties with the types of farmers or dealers who had their seeds tested, they are instructive nonetheless; it was just these testing-minded farmers that Biffen was trying to reach. Of the varieties tested in 1923, Yeoman made up 20% and Little Joss 9%.³⁶ Their main competitor, Red Standard, released by the commercial nursery Carters', made up 24% of tested samples and Squarehead's Master 11.5%. However, according to Biffen, these were one and the same variety, as Carters' had simply renamed Squarehead's Master.³⁷ The rest of the samples were made up of Victor and Marshal Foch; Mendelian wheat varieties produced by another commercial nursery, Gartons'; and the original Squarehead and Rivet, two varieties from the middle of the previous century. In 1929, the first year in which the National Institute of Agricultural

Botany produced lists of recommended varieties for farmers, Little Joss and Yeoman accounted for roughly 22% of the seeds tested by the Official Seed Testing Station. At the end of the Second World War, thirty years after they were released, Little Joss and Yeoman still made up 11% of the varieties in use by farmers who had their seeds tested.

Statistics produced in 1933 by Britain's leading agricultural economist of the day, J.A. Venn, suggest that in 1925 Little Joss and Yeoman occupied 25% of the wheat acreage in the south-eastern counties.³⁸ Venn's data was drawn from agricultural returns completed by farmers. On several occasions Biffen's colleagues, F.L. Engledow and E.S. Beaven, asked farmers to complete questionnaires on the types of varieties they were growing.³⁹ Farmers mostly resisted such requests; however, one further survey undertaken by the Ministry of Agriculture in the early 1920s supports the figure produced by Venn.⁴⁰ In both Venn's and the Ministry's figures it is clear that Yeoman was mostly grown in the rich loam soils of Essex and eastern Hertfordshire. Little Joss was more popular in the fens around Cambridge, where soil was of poorer quality.

One further mark of Yeoman's popularity with farmers is noteworthy. On 16 December 1921 Biffen and Yeoman were awarded a silver bowl by the Essex Farmers' Club. The bowl, weighing 82oz., was offered up and explained as recompense, as 'this great research has been without any financial gain'.⁴¹ The nature of the occasion, held at the Shire Hall in Chelmsford on Christmas market day and pontificated over by the local dignitary Hon. E.G. Strutt, was a provincial affair to recognise the success of Yeoman on a local level, in Essex.

The use of Mendelian varieties

Considering how Biffen's varieties were meant to be used, and their popularity with farmers, we might expect to see an increase in yields following the widespread adoption of Little Joss (as losses to disease were avoided) and an increase in price following the adoption of Yeoman as Runciman had promised.⁴² Instead, the acreage under cultivation and national production levels tracked each other pretty consistently through the period, indicating a consistent yield per acre. As to the promise of increased prices, small gains during the war can be attributed to the government's offering guaran-

teed prices for wheat from 1917.⁴³ A decline in prices occurred in 1922 after the removal of these measures with the repeal of the Corn Production Act in 1921.⁴⁴ Further slight gains in price in the mid-1920s were attributed by the Linlithgow Committee to bad weather. Despite the Committee's hopes, these increases were not the result of millers' offering more for Yeoman wheat. The few co-operatives established to grow and mill all-English flour had been unsuccessful.⁴⁵

At the Farmers' Club meeting in 1924, which this chapter began with, Biffen did not have the evening entirely his own way. Two farmers, Mr Patterson and Mr Sherwood, pointed to the success they were having growing wheat for chicken feed and straw. Patterson was growing Rivett for chicken feed and Sherwood was growing Little Joss for thatching straw. A glimpse of the tensions which underwrote this encounter can be seen in Biffen's arch response about feeding the human subject, made in reply to Patterson's assertion that he was making more money from growing wheat for chicken feed. Patterson snapped back at Biffen, '[Yeoman] will not do on my light land.'⁴⁶ Finally, Alfred Amos, author of a report on the success of Yeoman published in the *Journal of the Board of Agriculture*, came to Biffen's aid, pointing out that the mixing of wheat varieties on the farm and at the mill was actually the cause of millers' reticence to pay a premium for Yeoman.

Farmers such as Patterson and Sherwood were responding to a pre-war pattern of agricultural development. The total acreage of wheat in Britain was in decline; from 1885 to the start of the war half a million acres were lost.⁴⁷ Faced with competition from abroad and government resistance to applying import tariffs (fearing the renewed free-trade movement), farmers moved to other crops. Those who continued to grow wheat often moved their crops onto poorer land, freeing up prime space for more remunerative, or less input-intensive, purposes such as rearing cattle. This move was encapsulated in the slogan, 'Down Corn, Up Horn'.⁴⁸ In this agricultural context, Little Joss came into its own not because of its disease resistance but because the variety flourished on poor soils without much fertiliser. The variety was good only for chicken feed or making biscuits, neither of which paid as highly as bread making, but if growing Little Joss required fewer inputs, then this loss of price was often acceptable to farmers. By 1919 the Ministry of Agriculture was recommending Little Joss on the basis that it

was a 'hardy variety' that did well on poor soils, while 'it is too weak in the straw for rich land'.⁴⁹ The war also increased demand for biscuit flour and Little Joss was recognised as a variety which produced flour well suited to biscuit production.⁵⁰ Furthermore, when compulsory ploughing-up of land for conversion to cereal crops was introduced by the government in 1917, large amounts of less-fertile land needed to be planted and Little Joss was often the variety of choice.⁵¹ Finally, Little Joss's weak but lengthy straw was ideal for thatching, and this was another option for farmers such as Sherwood.⁵²

Yeoman was also used by farmers in ways which were not principally intended by Biffen. Two of the most striking patterns of agricultural development in the first half of the twentieth century were increasing farm size and, after the war, increasing ownership of farms by farmers who had previously been tenants.⁵³ Financially the war was a good thing for many farmers, as production increased and prices were fixed. As a result many farmers looked to own their own farms, increase their acreage and farm more intensively.⁵⁴ Yeoman was well suited to this trend. Its shorter straw meant that farmers could use larger amounts of fertiliser without the increased weight causing the plant to fall over and become laid. As the Ministry of Agriculture put it in 1924, 'Yeoman excels in milling quality, and also in strength of straw – an important consideration for the farmer who desires to make the best use of artificial fertiliser.'⁵⁵ Despite millers' unwillingness to pay a premium for Yeoman, larger crops still meant better profits, even if a farmer could sell his crop only for chicken-feed prices. In 1930, when the National Institute of Agricultural Botany released its list of recommended varieties, both Little Joss and Yeoman featured: 'Little Joss should be chosen for the lighter wheat soils ... or where fertility is low', Yeoman was one of the 'varieties to grow on the richest soils or under intensive manuring'.⁵⁶

From the 1930s, tractors increasingly became a feature of intensive agricultural production. Tractors supplemented the labour needed to fertilise and harvest large crops after the war, when manpower and horses were in short supply.⁵⁷ Although many farmers returned to draught power as horses became available again, the richest continued to use tractors. For those farmers who used tractors and combine harvesters, Yeoman was the wheat variety to choose. It was less likely to be laid and, furthermore, its short

straw reduced the amount of by-product material that needed to be processed, helping the combine to run smoothly.⁵⁸ Yeoman and mechanisation were part of the same system of intensive farming which was increasingly employed after the war. This, rather than the All-English solution, was the pattern of farming into which farmers integrated Yeoman.⁵⁹

Biffen became sanguine about the failure of the All-English loaf towards the end of the 1920s. Writing for the *Yearbook and Annual Report of the Essex County Farmers Union* in 1930 he looked approvingly to a competition that had been held in Italy in the previous year.⁶⁰ The idea behind the competition was to test the use of heroic quantities of fertiliser on wheat crops. Those involved, including Professor Gibertini, a ‘scientific propagandist’, had produced yields of up to eighty bushels per acre. This result inspired Biffen to revise his previous view that the wheat plant had reached its yielding capacity, ‘The fact that it is possible to produce such crops’, as indeed it was for some farmers in Essex, was for Biffen ‘clear indication that the wheat plant – using the word for once in a double capacity – is not often forced to run at its full capacity, and that more might be made of the uncanny machinery which produces grain from raw materials present in the air and soil’.⁶¹ Instead of advising farmers to grow stronger wheats, a strategy which disappeared from his public appearances, after 1926 Biffen began advising farmers to grow more intensively for greater yields.

Conclusion

Biffen’s Mendelian varieties were popular and agriculturally important, but not for the reasons Biffen had intended. Before the First World War, and for poorer farmers, Little Joss was used to lower production costs in response to competition from the New World. After the war, Yeoman allowed richer farmers to move to more intensive patterns of production. In contrast, the traits that Biffen aimed to improve – disease resistance and strength – remained secondary considerations for most farmers until the rust epidemics of the 1950s and the introduction of the Chorleywood bread-making process in the 1960s (which finally allowed the first home-grown white loaves to be produced).⁶² However, there is still much to be learnt about the choices farmers made. One way of getting closer to farmers’ motivations and thinking on how to farm wheat – which

lies beyond the scope of the current chapter – might be to track the diffusion of Mendelian varieties through an analysis of farm account books.⁶³

The ambiguity about who Biffen's attempts at governance through science were serving and how – revealed at the Linlithgow Committee's deliberations – is part of a familiar theme in the history of technology. Biffen's varieties, aimed towards particular ends, chime with Langdon Winner's description of the low overpasses on bridges to Long Island.⁶⁴ Winner uses the example to argue that technologies are not politically neutral. Biffen's varieties, aligned with a particular vision of agricultural development, are equally important, although less obvious, examples of politically charged technologies – something which they share with Monsanto's new varieties in the twenty-first century. However, farmers' ability to co-opt Biffen's varieties to their own ends should remind us that users matter, often because of their local knowledge.⁶⁵

Another way of charting the territory occupied by Biffen's varieties is to contrast determinist views of technology, which posit that a technology determines its uses from a position somewhere outside of society, with social constructivist analyses which suggest that technology is socially shaped by user communities, and structuralist views of technology that suggest social structures determine a technology's use. In the case of Biffen's varieties all three views have some relevance. On the one hand, farmers could not use new varieties as communication devices, or telescopes, or airplanes. Their use of Biffen's plants was at least partly bounded by biological reality. Furthermore, Biffen was ultimately responsible for the shorter straw of Yeoman or the hardness of Little Joss, even if he did not take these to be the key features of the varieties. Finally, although farmers were creative with their use of Biffen's varieties, they were themselves responding to the structural demands of an increasingly capitalised and industrial agricultural sector. To be sure, Biffen was an agrarian idealist; however, he was also committed to the industrialisation of agriculture, as his reference to the plant as machinery indicates.⁶⁶ One suspects that the bread battle was a small loss for Biffen in the greater war to develop a modern agriculture.

For historians of genetics the history of Biffen's Mendelian varieties makes obvious geneticists' desire to change agriculture, right from the start of the discipline. Debates in the twenty-first century over genetically modified organisms, biofuels and climate change

have brought the political nature of land use back into the spotlight. The case of Biffen's varieties and their use by farmers serves to remind us of the historical pedigree of such debates, but also of the contingent and unpredictable nature of technological fixes.

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Notes

- 1 On historical food riots see E.P. Thompson, 'The moral economy of the English crowd in the eighteenth century', *Past and Present*, 50 (1971), 76–136. For analysis of the relationship between hunger and politics in the twentieth century see, James Vernon, *Hunger: a modern history* (Cambridge, MA: Belknap Press, 2007); Nick Cullather, *Hungry world: America's Cold War battle against poverty in Asia* (Cambridge, MA: Harvard University Press, 2011). The food riot is still with us; in 2008, on the heels of the global financial crisis, a series of food riots occurred in countries ranging from Italy to Haiti. See Raj Patel and Philip McMichael, 'A political economy of the food riot', *Review (Fernand Braudel Center)*, 32 [Political economic perspectives on the world food crisis] (2009), 9–35.
- 2 On the rise of modern bread in the United States, see Aaron Bobrow-Strain, *White bread: a social history of the store-bought loaf* (Boston: Beacon Press, 2012). On French bread, see Steven Kaplan, *Good bread is back: a contemporary history of French bread, the way it is made, and the people who make it*, trans. Catherine Porter (Durham, NC: Duke University Press, 2006). For a contemporary account of British bread from Cambridge University's first Chair of Agriculture, see Thomas Wood, *The story of a loaf of bread* (Cambridge: Cambridge University Press, 1913). Finally, on white food, see Sidney Mintz, *Sweetness and power: the place of sugar in modern history* (London: Penguin, 1986).
- 3 See, for example, the agitations of the Home Grown Wheat Committee,

- regularly reported in *The Times*: ‘Home Grown Wheat Committee’, *The Times* (28 August 1911), 4.
- 4 See Berris Charnley and Gregory Radick, ‘Intellectual property, plant breeding and the making of Mendelian genetics’, *Studies in the History and Philosophy of Science: Part A*, 44 (2013), 222–33.
 - 5 The standard source on science and modernity is Bruno Latour, *We have never been modern*, trans. Catherine Porter (Cambridge, MA.: Harvard University Press, 1993). For an authoritative overview of some of the rest of the extensive literature on science and modernity in history of science and sociology, from a critical gender standpoint, see Sandra Harding, ‘Modernity, science and democracy’, *Social Philosophy Today*, 22 (2006), 17–42.
 - 6 On this historiography, see Berris Charnley, ‘Agricultural science and the emergence of a Mendelian system in Britain, 1880–1930’ (PhD dissertation, University of Leeds, 2012).
 - 7 R.H. Biffen, ‘Modern wheats’, *Journal of the Farmers’ Club*, 1 (1924), 1–18, esp. p. 18.
 - 8 Paul Brassley, ‘Output and technical change in twentieth-century British agriculture’, *Agricultural History Review*, 48 (2000), 60–84.
 - 9 On the depression, see *Royal Commission on Agriculture: final report of Her Majesty’s commissioners appointed to inquire into the subject of agricultural depression* (London: HMSO, 1897). For secondary analysis demonstrating the depression’s limitation to arable farming, see Joan Thirsk, *Alternative agriculture: a history, from the Black Death to the present day* (Oxford: Oxford University Press, 1997).
 - 10 R.H. Biffen, ‘British wheat: improved methods of cultivation’, *The Times* (8 June 1914), 16.
 - 11 Biffen also experimented with wheat varieties that could be sown in spring, reducing time to harvest. See R.H. Biffen, ‘The selection of wheats for spring sowing’, *Journal of the Board of Agriculture*, 22 (1915), 867–71.
 - 12 R.H. Biffen, ‘Mendel’s laws of inheritance and wheat breeding’, *Journal of Agricultural Science*, 1 (1905), 4–48, esp. p. 4. A bushel of wheat is roughly 27kg; this measure is still used on commodities markets.
 - 13 See Berris Charnley, ‘Experiments in empire-building: Mendelian genetics as a national, imperial, and global agricultural enterprise’, *Studies in History and Philosophy of Science: Part A*, 44 (2013), 292–300.
 - 14 Biffen also served two terms as president of the British Mycological Society; one at the beginning and one at the end of his career.
 - 15 See R.H. Biffen, ‘Bunted wheat’, *Yearbook and Annual Report of the Essex County Farmers’ Union*, (1924), 129–34; ‘Rust’, *Yearbook and Annual Report of the Essex County Farmers’ Union*, (1929), 120–9.

- 16 Charnley, 'Experiments in empire-building', 298–9.
- 17 R.H. Biffen, 'Wheat breeding: read by R.H. Biffen, M.A., Emmanuel College, [Read 9th Nov. 1903]', *Proceedings of the Cambridge Philosophical Society*, 12 (1904), 279–82, esp. p. 279.
- 18 Ministry of Farming and Fisheries, *A century of agricultural statistics* (London: HMSO, 1967), 48.
- 19 R.H. Biffen and A.E. Humphries, 'The improvement of English wheats', *Journal of Agricultural Science*, 2 (1907), 1–16, esp. p. 2.
- 20 'Official notices and circulars: new wheats', *Journal of the Ministry of Agriculture*, 26 (1919), 457–66, esp. p. 458.
- 21 'Board of Agriculture and Fisheries (Class II. – VOTE 11.)', *Hansard*, 55 (1913), 2320.
- 22 'Wheat wizard: Sir R.H. Biffen's new grain', *Daily Mail* (2 January 1925), reproduced in John Innes Archives, Norwich, Rowland Biffen Papers, *Extracts from Newspapers on Wheat Research of Professor Sir Rowland Biffen MA FRS, Cambridge University*. See also the articles on the All-English campaign collected at the National Institute of Agricultural Botany from newspapers as diverse as the *Daily Mail*, *The Times*, *Macclesfield Courier*, *East Kent Gazette*, *Banbury Advertiser*, *Farmer and Stockbreeder* and the *Essex Weekly News*, reproduced in NIAB-TAG, Cambridge, *Newspaper Cuttings*, NIAB Archives, main library section.
- 23 Ministry of Agriculture and Fisheries, Departmental Committee on Distribution and Prices of Agricultural Produce, *Interim report on cereals, flour and bread*, Cmd. 1971 (1923), p. 73.
- 24 Ministry of Agriculture and Fisheries, *Interim report on cereals, flour and bread*, 73.
- 25 For more on home-grown wheat and conflicts between millers, bakers and farmers, see S.L. Bensusan, 'The staff of life', *Saturday Review of Politics, Literature, Science and Art*, 152 (1931), 176–7.
- 26 Ministry of Agriculture and Fisheries, *Interim report on cereals, flour and bread*, 75.
- 27 On the Haber-Bosch process, see Thomas P. Hughes, 'Technological momentum in history: hydrogenation in Germany 1898–1933', *Past and Present*, 44 (1969), 106–32; David Edgerton, *The shock of the old: technology and global history since 1900* (London: Profile Books, 2006), pp. 64 and 67.
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