War, Wheat, and Crop Diseases of the Late Enlightenment: Contesting and Producing Evidence in Agriculture in Great Britain[1]

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Abstract (300 words)

One of the central philosophical problems of the Enlightenment was the relationship of evidence to the sense faculties and observation. As the authority of natural philosophy became a tenable political force in Britain, the question of how we arrive at knowledge through the action of reason and rationality became inextricably tied to many of the central questions facing the British state. The late Enlightenment was also a period characterised by fears that crop diseases and poor weather threatened the survival of the British state, bringing agricultural practices and the cultivation of foreign plants under the scrutiny of institutional and state powers. This chapter surveys the different evidence cultures that were contested and developed during the close of the eighteenth century, when the dual threats of war and famine gave rise to the Board of Agriculture in 1793. The Board of Agriculture was established by the British parliament to produce statistical surveys of Britain's agricultural output and also to identify scientific cultivation practices for increasing yields; but from its inception, the nascent Board of Agriculture found itself to be heavily dependent upon the observations and expertise of practicing farmers. This led to a crisis within the Board's efforts to promote scientific approaches to cultivation. In the absence of so-called 'experimental farms', how, precisely, did the observations of practicing farmers constitute evidence supporting their own cultivation practices? In the efforts of the Board to develop scientific accounts of crop diseases attacking staple varieties of wheat and potatoes, the validity of evidence and the question of its provenance and its legitimacy all came into sharp contrast. In the effort to enlist Britain's farmers into the ranks of scientific practice, the field became a key site where Enlightenment-era ideals served mediating roles between traditional evidence practices and local knowledge.

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Introduction

'The popular notion amongst farmers, that a barberry tree in the neighbourhood of a field of wheat often produces the mildew, deserves examination.'[1]

In 1804, in a crowded lecture hall in London, the chemist Humphry Davy delivered a series of lectures on agricultural chemistry, during which he called for further investigation into the popular belief that common barberry could produce mildew in wheat fields.[2] The comment might seem speculative, academic, even trivial. But during Britain's involvement in the Napoleonic wars, the debate over barberry was a central scientific topic, and everyone from illiterate farmers to the President of the Royal Society weighed in on the question of whether or not the cultivation of barberry in Britain was threatening its food security. The idea that barberry shrubs, just by being 'in the neighbourhood' of a field could affect it seemed, to many people, delusional. 'I believe a similar prejudice formerly prevailed against beings equally harmless and innocent,' wrote one farmer in defence of barberry, 'many of whom were put to death by "judicial authority", under the charge of *witchcraft.*'[3] The agricultural press of the eighteenth century was voluminous: popular treatises on farming, encyclopaedias, and periodicals flooded the print culture of London, although few practicing farmers looked to the advice emerging from agriculturalists as a means to increase their yields and income.[4] What agricultural print culture did provide was a space for political debate over land management and food production: the agriculturalist Arthur Young rose to fame not for his views on turnip cultivation, but for the tours of farmland he undertook in France on the eve of Revolution.[5] Disease, and its causes, were no less political than revolution. As agricultural writers, natural philosophers, botanists, and practical farmers took sides on the question over barberry, the fraught and complex means by which evidence was weighed, considered, or discounted in agricultural science, unravelled.

The food shortages and riots that affected Great Britain at the close of the eighteenth century, (explored in their full significance by the historian Adrian Randall's work on popular protest), threatened on numerous occasions to pitch the country into revolution (or at least, so it seemed to many within the political elite).[6] The causes of these shortages were complex, and historians disagree as much today as to their cause as did people at the time; population growth, crop failures, agricultural mismanagement, the engrossing of grain by landowners, disruptions in the food trade due to war.[7] But during bad seasons where excess rains, cold weather, or drought affected crops, the ravages of crop diseases on wheat fields were painfully visible to the public, and often positioned by contemporaries as playing key roles in driving shortages and risking famine. Famines were still regular occurrences both within Europe and within the wider British Empire in the eighteenth century, and while historians of famine are agreed that England did not suffer a 'famine' again after the sixteenth century, the threat of famine remained immediate and politically potent.[8] The absence of a census or reliable data on food production before 1801 made these fears all the more acute.[9] This political interest in agriculture helped provide funding, state support, and widespread interest in experimental or scientific agriculture—derided as 'book-farming' by sceptics and critics.[10] The 'agriculturalists' or 'agronomists' that wrote on agricultural matters for the scientific magazines, journals, treatises, and surveys that proliferated during this period all worked to enlist travel, circular letters, and surveys into this effort to develop a base of scientific agricultural knowledge.[11] This chapter explores the controversies and arguments that split these emerging scientific networks over the causes of diseases in wheat—particularly stem rust and its relationship to

barberry. *Puccinia graminis* (stem rust) is a fungus that attacks wheat plants. Its life cycle incorporates *Berberis vulgaris,* or common barberry, as a host during winter in temperate climates. While many agricultural communities the world over understood that barberry had the power to affect and spread disease amongst wheat fields, agriculturalists remained deeply sceptical of these claims, rejecting them even when advanced by the President of the Royal Society, Joseph Banks.

This was not because agriculturalists were more inclined to rational explanations and practicing farmers more open to tradition and local wisdom. There were no experimental farms in Britain in the eighteenth century: the only people that possessed any knowledge on agricultural cultivation methods and practices were the farmers themselves. Moreover, this was an era where botanical and agricultural knowledge was often communicated and diffused in poetry, at least within the print culture active in Britain. Alongside the botanical poems of Erasmus Darwin, most of the agrarian and agricultural writers of the eighteenth century had a classical education and were familiar with Virgil's *Georgics,* and also the name of the Roman god Robigus, who protected wheat from rust and mildew in the Roman era.[12] In the eyes of many, the preventative measures and practices adopted by farmers in England to mitigate against the impact of the disease were no more effective or rational than the animal sacrifices practiced by Romans at the ancient *robigalia*. In particular, the belief held by many farmers in Britain that *Berberis vulgaris,* or barberry shrubs, infected or transmitted mildew and rust to cereal crops, was viewed as symptomatic of superstition and ignorance.

When we look to larger historical studies of science in the eighteenth century, we see these contests over evidence and authority held significant political importance. Simon Schaffer has argued that science in the eighteenth century was founded upon (what he termed) 'a practice of public display.'[13] Spectacle and display provided evidence to fuel scientific debates, but were also arenas of political and social conflict. Evidence, far from inviting consensus, could threaten the status quo, inviting the powers of institutions – and sometimes the state—to work towards establishing consensus.[14] Jessica Riskin's work on the role of the senses and sensibility in scientific thought in the eighteenth century has shown how fraught questions of how to interpret evidence produced by the senses could be in this period.[15] Riskin and Schaffer were both concerned with the idea of spectacle as a small experiment being performed by a natural philosopher (or a charlatan) before the public: but outbreaks of wheat rust were also spectacles, witnessed by a wide public, where it was important for political powers to ensure some level of influence over how people understood the catastrophic operations of nature.[16]

A brief revision of agricultural production in Britain is important here. The eighteenth century saw most land in Britain in the hands of a select and wealthy few.[17] This is a period where landowners were in the process of petitioning parliament for the right to enclose land. Historically, tenants had use of commons pasture to keep cattle and livestock. In the fens, "common wastes" or "waste lands" (usually encompassing pasture, commons, fens, uncultivated farm land, and forest) provided land for peasants and tenants to hunt and grow crops—the enclosure of land by owners ushered in crop rotation, an emphasis on cereal cultivation, and was viewed by its critics as encouraging the depopulation of the countryside. By 1800, agriculture was still the largest employer in Britain and wheat was the largest component of national income.[18] Studies of the self-sufficiency of Europe have shown that despite the population explosion between 1750-1850 Europe was most certainly self-sufficient, although Britain had the largest deficits in grains, with imports averaging 1.4 million tons.[19]

If the island was struggling to produce sufficient grain, it was prolific in its production and diffusion of agricultural journals, pamphlets, and treatises. Joanna Innes, writing on social problems of the eighteenth century, regarded the success of agricultural printing as tied to a wave of concerns that brought agriculture to the focus of attention: rising food prices and the concern of advances in agricultural production on the continent. [20] Paul Warde has argued that in the eighteenth century, British agriculturists for the first time began to regard agronomy as 'a generalised theory of the management of agrarian resources.'[21] Agricultural writers often sought to identify principles and techniques that had universal merit, but even the least knowledgeable writers admitted that soil type and local circumstances would ultimately determine the suitability or unsuitability of cultivation methods: the main distinction between clay and calciferous soils of lime and chalk determined what farmers did and did not attempt to grow in their own regions.[22] Efforts to generalise and derive principles for agriculture were perpetually fractured and rendered uncertain by the question of local circumstances: practices that went against the grain of general opinion might prove somehow suited to some unknown or important aspect of locality. Other historians have pointed to the more immediate financial aims of agriculturalists. Successful writers like Arthur Young often began writing agricultural treatises in the first place in the hopes of finding wealthy sponsors to hire them as estate managers. Pamela Horn termed this generation of agricultural writers 'propagandists', viewing the output as primarily political and self-serving, with little hope or actual intention of reaching the hands of farmers.[23]

Despite the proliferation of manuals and literature aimed at agricultural improvement addressed to 'the public', it is obvious that most of the labourers and tenant farmers are not actually intended to be part of this public, despite the fact that they carry out most of the labour and planning in agricultural production, and possess most of the cultivation knowledge. Landowners, the clergy, estate managers, baileys, (those charged with overseeing practical management of larger farms), engineers (in charge of draining), gardeners and Yeomen constituted the public, although the question of how to talk to those that actually worked the land was a frequent one. The questions that plagued Britain in the eighteenth and nineteenth centuries concerning land management, particularly because all of the questions concerning improvement, progress, feeding the population, and ensuring the survival of the landed gentry against revolution and reform convene in the question of how agricultural land ought be cultivated.

If practical farmers were excluded from the agricultural sphere in principal, they still played a crucial role in producing knowledge and in implementing the kinds of practices and approaches that British agriculturalists hoped to see adopted throughout the kingdom. This led to an epistemological crisis: the validity of evidence was constituted by the education, social standing, and methods adopted by the farmer. This is unsurprising in itself. But the necessary role played by practical farmers in observing and informing agricultural writers on cultivation methods destabilised this culture. While practical farmers were often discounted in the print culture as illiterate, 'ignorant', and stubborn, they still had some power in negotiating evidence practices. Agricultural writers such as William Marshall not only relied on agricultural labourers to conduct his experiments, but also designed and carried out cultivation experiments to test the veracity of practical knowledge according to scientific means. Scientific authorities like Joseph Banks invested in illustration and the use of microscopes to work to verify the claims of practical farmers along similar means. In this chapter, I show how the emergence of an agricultural print culture produced a discursive space in which evidence was produced and contested concerning the relationship between barberry, disease, and Britain's

food production. Ultimately, this discursive space worked to conceal and obscure the relationship between barberry and crop disease, and it also worked to discredit and belittle the knowledge held by practical farmers, despite the fact that these persons were at the same time providing the vast majority of cultivation practices, observations, and techniques that agriculturalists drew upon in describing rational or experimental agriculture.

Crisis

It is important to provide some context for the arguments and debates over barberry during this period, as they were far from idle speculation happening within botanical, gardening, and agricultural circles. Britain had been dependent upon wheat imports since the 1750s, but war with France and reports of food shortages and famines on the war-torn continent provided extra motivation for the argument that Britain should convert its wastelands and pasture towards cereal cultivation, wherever possible.[24] The frequent crop losses that struck Britain in the latter half of the eighteenth century tended to encourage Britain towards increased wheat cultivation, rather than diversify cultivation—many agriculturalists urged the government and agricultural societies to nudge farmers towards other staple crops, like potatoes, oats, and barley—but the politics of bread ensured that the only viable political response was to work towards increasing wheat production.[25] After the failures of 1795, the Board of Agriculture established a committee on the improvement of these so-called 'waste lands' with the direct aim of expanding cereal cultivation.[26] The belief that enclosure and cereal cultivation could provide Britain with military and economic domination over its competitors was nothing new—as Young argued in his first agricultural pamphlet in 1768, 'it would be most political conduct to turn all the commons and sheep-walks in the kingdom into arable farms.'[27]

Wheat prices rose and crashed during the eighteenth century, threatening food riots and shortages during bust periods and the financial viability of cereal cultivation when seasons were abundant. In 1786, wheat sold for an average of £575 pounds per tonne; by 1789 it was £772. The price fell to £603 in 1792 only to rise to £875 in 1795-6.[28] The range of public debate over the cause of these price shifts demonstrates that there was no consensus as to whether or not the shortages and prices were primarily the result of bad weather and natural causes, agricultural incompetence and mismanagement, or human greed. As the harvest of 1793 looked to be disappointing, the *Evening Mail* reported in late September that 'the immense quantity of horses in this country are, in a great measure, a principal cause of the high price of provisions.'[29] In April 1796, members from Leicester and Worcester proposed a tax upon dogs, reasoning that uneaten food from the tables of the rich went first to their dogs, and secondly to the poor; if they felt pressed to keep fewer dogs, more scraps would be available for poor families.[30] As historians of rural riots have shown, many communities were convinced that the shortages were the direct result of hoarding by wealthy farmers and grain merchants, deliberately driving up prices in pursuit of wealth.[31] If newspapers and agricultural journals provided space for conjecture and speculation about contributing causes, the stamped press and institutions like the Board of Agriculture were largely agreed that (a) the shortages were very real, and (b) they were primarily the result of poor weather, but certainly aggravated by bad cultivation practices. The survival of the state and the protection of property both necessitated that cereal yields increase.

If agricultural writers pointed towards numerous and contradictory causes of the shortages, there was nonetheless widespread agreement that failed wheat crops were

blighted, mildewed, and blasted. The significance of crop disease as a catalyst in the failures is evidenced by the speculative agricultural technology of the period. In 1789, Young reported that a citizen of Augsburg (north of Munich) had invented an engine that could clean smutty corn 'in a few minutes.' Excited by the news, Young speculated that the engine, if used across Britain, then even if smut couldn't be eliminated from agricultural practice, at least it would be possible to save more food from infected crops.[32]

An epistemological crisis accompanied these crop failures: there was no consensus as to what symptoms belonged to 'mildew', 'blight', 'smut', and 'rust', if these named one malady, several, or four separate diseases. Virgil's *Georgics* made reference to *robigo* attacking wheat, and was translated by Dryden as: 'Soon was his Labour doubl'd to the Swain, and blasting Mildews blackened all his grain.'[33] Grey, yellow, reddish, and black ailments, sometimes affecting the stem, sometimes the leaves, other times the kernel—the taxonomies we use to separate these fungi today were unavailable, although agriculturalists and poets alike were interested in what the different colours and areas of the plant affected might betoken. Since at least the time of Samuel Hartlib, agricultural writers and botanists had tried to define and untangle these diseases, but as reportage on outbreaks in Britain took up whatever terms locals used to name the malady affecting their crops, the terms remained puzzlingly interchangeable. A farmer named Mr Aiton wrote to *The Farmer's Magazine* to report failures to mildew in his area, but warned readers that: '… diseases termed blight, rust, mildew, &c. -- Whether these ought to be ranked as one, or as so many different diseases in growing crops, is not for me to determine.'[34] When the botanist and Anglican minister John Henslow tried to separate and distinguish the different fungi attacking cereal crops, he determined that 'mildew' was the most common term used for the effects of *Puccinia graminis* (stem rust).[35]

Everywhere, wheat rust was felt to be increasing. Losses to crop disease were so thorough in Yorkshire in 1795 that the president of the Board of Agriculture, John Sinclair, said that farmers in the district should seek fresh seed from other counties 'at any expence.'[36] Within the public sphere, degeneration in seed stocks and appeals to miasmatic theories of infection were most popular, leading some newspapers to advise affected areas to import untainted seed. The *Telegraph* advised readers after the summer harvest failures of 1795 that:

> …none but the best seed should be made use of…In some parts of the kingdom, particularly in Yorkshire, the mill-dew has been much complained of.. Any seed infected with that disorder ought to be avoided as much as possible, and untainted seed, at any expence, ought to be procured.[37]

Parliamentary records and discussion in the press affirm that 1796 saw farmers responding to what they understood to be government directions to grow wheat on their land, no matter if it interrupted their usual rotation schedule, with the result that cultivation of wheat (often on exhausted soil) certainly increased from 1796 onwards. Few observers felt that the crops of 1796 provided evidence that wheat was thriving in Britain.

Echoing 1795, the crop failures in 1804 in Britain were observed by Joseph Banks to have been principally caused by 'the mildew.'[38] Arthur Young circulated a request for information on the English wheat crop that began with the observation that: 'the mildew on wheat has rarely been so general or fatal as in the late crop of 1804'.[39] In 1806, landowner and agriculturalist John Egremont proposed a series of measures to treating infected crops in the hopes that 'that they would not be felt as a national calamity.'[40] The unusual weather patterns in Britain from 1800-1817, including unseasonably cold and wet years, followed in 1816 by 'the

year without a summer', saw agricultural writers observing that 'It is an unquestionable fact, that the Rust has made more considerable ravages within the last ten or twelve years.'[41] The fact that war and shortages had pressed many farmers into growing wheat on exhausted land was observed at the same time, and lent renewed support to theories that the disease was produced by degeneration in the seed or depletion of the nutrients in the soil.

Cultures of Evidence

How, precisely, did agriculturalists propose scientific responses to the threat of wheat rust during this period? Recent historiography has shown how central agricultural production was not only to political discourse, but also to the philosophical discourse of the Scottish and European Enlightenment. Fredrik Jonsson has argued that the Scottish Highlands became the 'practical laboratory' for many of the political and philosophical ideals of the Enlightenment.[42] Land management, agriculture, population studies and even efforts to re-forest the mountainsides all provided a means where the ideals and politics of philosophers found a means of testing whether there were natural limits to improvement.[43] Many agriculturalists of the era prized experimentation as a means to test these limits, but all agreed that the state had failed to provide adequate financial support in this regard. While agricultural writers such as the intelligencer Samuel Hartlib had called for the establishment of schools for husbandry and agriculture since the 1650s, by the close of the eighteenth century Britain still lacked such an institution. Writing in 1799 and calling for the establishment of the same kind of husbandry school Hartlib had recommended 150 years prior, the agriculturalist William Marshall insisted that its political necessity was very clear: 'England, at present, does not produce a supply of food for its own inhabitants.'[44] Marshall, as Hartlib before him, viewed the potential school as a site of research and scientific education for farmers, estate managers, and even laborers — the possibilities of such an institution were pressed in utopian terms, 'the whole kingdom will become systematized.'[45] But it did not exist, and lurking behind descriptions of this idealised system was the complex web of print culture that constituted the exchange of agricultural knowledge amongst the educated classes.

With no experimental farms and very few farmers in a position to undertake the financial risks of experimenting with untested cultivation methods, agricultural print culture in the eighteenth century was composed of evidence provided by practicing farmers. Agriculturalists took it upon themselves to sift through testimony and observations, separating the useful from the spurious and the false. Many were eager to enlist philosophical concepts and methods in this effort to manage and limit the amount of influence practical farmers could have on the science taking shape in their publications. So-called 'book farming', 'experimental farming', or 'the new husbandry', referred to a constellation of books and treatises, gentlemanly societies, fads, and communication networks which encouraged land owners to manage their estates according to rational principles and scientific knowledge, rather than to trust to the local practices that tenants and farm laborers were apt to follow.[46] As Jürgen Habermas has argued, this capitalist public that owned the land (and debated the virtues of experimental farming) were 'a reading public.'[47] Agricultural books and treatises abounded, but a few figures nonetheless sought to dominate the public debate over agricultural practice and to direct public opinion. Agricultural writers (such as William Marshall) worked to delineate and identify scientific agricultural practice by appeal to the methods and processes by which such literate farmers gained knowledge:

> —the ILLITERATE FARMER either acts wholly by CUSTOM; or, if he observes advertently, trusts his observations to his MEMORY. The SCIENTIFIC FARMER, on the contrary, not only observes and records the useful information which occurs to him in the course of his practice, by INCIDENT ; but discovers by EXPERIMENT, those valuable facts, which never did, nor ever might have come, incidentally, within his knowledge.[48]

Thus, experimentation – and proper consideration of evidence—were central to Marshall's vision of the habits and practices that distinguished the scientific farmer. These practices were all the more important given the absence of the kind of schools that could otherwise establish the methods and practices of agriculture. Whatever 'evidence' in agricultural science might mean, agriculturalists recognised that the reading public were in the position of power to weigh and consider it.

Efforts to square and define 'evidence' by philosophers in this period often served to reinforce the same means of consideration that agriculturalists were inclined to take concerning political economy, food, and the causes of rising prices. David Hume divided evidence into three kinds: evidence produced from knowledge, evidence that arises from the exercise of geometrical and logical proofs, and evidence that arrives 'from probabilities.'[49] The last form of evidence comprised all that evidence drawn from arguments of cause and effect, building on perceptions in the mind. Perhaps unsurprisingly, Hume's views on evidence and its role in the processes of reason led him to conclusions shared by most of his peers. Thus, in his historical account of agriculture in England, Hume viewed economic data of shifts in the price of grain as 'sufficient proofs' that no cultivation practices had been developed to make any progress against weather fluctuations.[50] Likewise, Hume viewed high prices of wheat and periods of documented famine as 'a certain proof of bad husbandry.'[51] But if the increased attention to evidence and processes of reason made little difference on how Hume and his followers understood the operations of nature, the attention paid here to how evidence might sufficiently prove the causes of famine or the consequences of poor husbandry established ideals that agricultural writers like William Marshall sought to attain in their own work. Judicious attention to evidence and the process of argumentation could, Marshall believed, distinguish the products of imagination from genuine agricultural truths: a key ability to wield, in Marshall's eyes, when all the cultivation knowledge was wielded by those carrying out the work. But the limitations of such methods were hotly debated. Writing on individuals that argued from the basis of their own experience, the agriculturalist Arthur Young commented that: 'I have nothing to say to gentlemen who are rather inclined to credit their own insulated experience upon some scrap of land, compared to whole counties.'[52] Young certainly encouraged 'superior minds' and those with the money to engage in it to undertake experiments. But since he viewed differences in soil and climate as hard to control, he doubted the ability of the best-intentioned farmers to be able to conduct trials that could be meaningfully repeated with hopes of success in other parts of the country where conditions would differ.[53]

The Debate over Barberry

Despite its occasional representation for witchcraft, Barberry was widely cultivated in Britain during the eighteenth century. The berries produced by the shrub were described in recipe books and gardening treatises all included advice, recipes, and uses for barberry during this period.[54] The eighteenth century also saw continued and rapid enclosure of commons and waste lands in Britain, a process that involved farmers searching for shrubs (like the barberry) to be enlisted in growing hedges that could both separate fields and provide a means for cultivating useful shrubs and trees.[55] As there were no other examples of a cultivated plant species infecting or attacking another from a distance, the theory promoted by some that barberry could attack wheat seemed counter to the logic of nature. But it also provided a means of distinguishing expertise from ignorance, so long as the theory remained unproveable.

In the confusion, many were quick to attribute to farmers and laborers whatever theory they hoped to argue against, thus the Anglican minister Robert Hoblyn asserted that 'The practical farmer as invariably assigns it to the malignant effects of morning fogs, or, in other words, to atmospherical influence.'[56] But such views were held by the wealthiest landowners in the country as well, including the Earl of Egremont, member of the Board of Agriculture, who observed that 'the blight is generally immediately produced by excessive heat coming suddenly after much rain.'[57] A farmer in the south of England wrote to Arthur Young that his crop was subject to rust and mildew, which Young attributed to the influence of sea fogs.[58] Every step of cultivation was scrutinised and held in suspicion. Crops that were drilled were suspected of being more prone to rust, while others argued that crops sewn without seed drills were more at risk. [59] Farmers and landowners alike speculated on varietal differences—a variety named 'Creeping Wheat' from Yorkshire was celebrated as being less liable to rust, while varieties that were 'woolly-eared' or 'thick-chaffed' were singled out as being more at risk to the disease.[60] While some blamed sea airs, interviews with farmers in coastal areas were just as likely to support the belief that the salty airs preserved crops from rust.[61] An American correspondent suggested to Young that the rust might be attracted by clover, and that the increased cultivation of clover could explain the frequency of rust infections.[62]

The knowledge that wheat rust was transmitted from barberry shrubs to wheat crops was pervasive throughout farming communities in Britain, Europe, and North America. Agricultural writers and travelers, in compiling anecdotes and publishing letters from practicing farmers, frequently encountered records of how communities preserved knowledge of the dangers posed by barberry to wheat. Examples of such testimony abound in the agricultural press, but it is worth considering at least one example at length. A farmer in Leeds named John Baker recalled (in 1839):

> 'When I was a boy, I was taken by my father to a field of wheat, the middle of which, from side to side, was covered with mildew; a large barberry bush grew on one of the hedges near to a garden, and directly opposite to the portion of the field which was diseased, neither of the ends of the field being at all effected with the malady…we attributed it to the plant in question…Some years afterwards, I learnt from a botanical friend, to whom I had made some observations on the disease, that the mildew was a plant of the mushroom tribe, which fixed itself on the stem of the wheat, and that the same parasite found a harbour on the leaves of the barberry'.[63]

Such testimonies frequently appealed to the geometrical aspects of the infection in relation to barberry shrubs—the nefarious influence of the plants could be directly observed in the

patterns of disease in the fields. Baker learned from his father to see that this outbreak was downwind from the shrub, areas that were clear of the shrub also being clear of disease. Other practical farmers spoke of the relationship in similar ways. Young reported a landowner, upon purchasing a field, asking a farmer if it was prone to rust outbreaks. 'Oh! Replied the man, '*it is in such, and such a line,* and in that direction you will find two barberry bushes, which always mildew some of the wheat whenever it is sown.'[64] On the authority of the landowner (a Mr Sewell), the barberry bushes were removed and the field spared from future outbreaks. 'Late ripening oats,' observed a farmer, 'equally near to barberry hedges, suffer most by the local mildew, which extends as far, in some years, as a quarter of a mile at least and sometimes more, from the diseased and infecting hedges.'[65]

The farmer John Exter was particularly insistent that there was a geometric aspect to the relation of rust infections to wheat crops and the positions of barberry shrubs. In a detailed letter sent to Arthur Young, he explained that he had observed an outbreak of rust on his land that was most intense in the immediate circumference of the tree, growing fainter relative to distance. Most importantly, he explained that wheat growing behind barns and hay-stacks 'where it could not be seen from the spot the bush grew' were unaffected. 'It appears by this circumstance, that the influence of the Berbery is projected in a right line, as rays of light sent off from a luminous body, and that any refraction of its rays lessons, if not destroys, its effect.'[66] When William Marshall experimented by planting a small crop of wheat around a barberry shrub, he likened the resulting rust infection to the tail of a comet, observing that the rust hit the field like a tail pointing downwind from the barberry.[67] These observations were debated in the scientific press for decades, and as late as the 1850s botanists still rejected them, arguing that these effects could easily be explained by appeal to the shadow cast by the barberry, or the wetness of the soil.[68]

Among the farming regions that had maintained strict communal policies against the cultivation of barberry in Britain was Norfolk. Visiting the county in the 1790s as an agricultural writer, William Marshall clearly had never previously heard of the idea and expected that his readers would be unfamiliar with it as well. He explained in his account of the travel that he laughed in the face of the farmer who first expressed the conviction.[69] Enquiring amongst other farmers in Norfolk, Marshall realised that they were 'to a man, decided in their opinion.'[70] Marshall subsequently undertook an experiment to test the influence of the shrub upon wheat, and though he observed (as described above) just the kind of geometric relation between shrub and infected crop that many had described, Marshall rejected the evidence from his own experiment. Having strongly rejected the knowledge accumulated by illiterate farmers in his earlier publications, it is reasonable to conclude that Marshall enlisted scepticism on this point because he feared that agricultural practice in Britain was conducted more according to error than it was to truth. There remained something irrational in the suggestion that barberry shrubs could blight a field of wheat. The operations of nature ought to be intelligible.

Contrasted with experimentation were efforts to compile evidence and observations of the putative link between barberry and mildew. In 1804, crops failed throughout Britain due to poor weather. Arthur Young returned to the circular letter as a means of trying to gather evidence and establish consensus. He had no fears that his readers would not engage with the questions on the causes of rust and mildew—the failures of 1800-1801 and the previous decade all ensured that correspondents in his agricultural network had sufficient direct experiences of crop failures to draw upon. Moreover, these particular crop failures were

complicated by the approaching end of war with France, which spelled trouble for landowners and farmers that had profited from the soaring wheat prices of the past few years.[71]

Respondents could not be expected to answer all the questions; it was important to put the most important questions towards the top of the letter. Young's letter featured 12 questions. The first asked respondents to name the soil types most affected by mildew; the second question asked if early or late varieties were worse affected, the third asked after exposure to airs… it was only by the ninth question that Young demanded information on whether or not 'you made any observations on the barberry, as locally affecting wheat?'[72] Sent to pastors in rural communities, land owners, farmers, and other members of the Board of Agriculture, the circulars provide testament to the variety of beliefs and suspicions related to the causes of the maladies affecting wheat. The responses showed that few within the agricultural writing community were persuaded by the snippets of testimony and observation supplied by practical farmers in support of the barberry theory. John Egremont reasserted his belief in response to Young that 'the blight' was brought on by an excess of heat after rain. Thomas Estcourt also argued for climactic explanations, believing that chilling effects from cold rain led to the symptoms observed in affected fields. A farmer named George Sumner agreed with Egremont and Estcourt, saying that: 'I saw the mildew on the chalk, on the wet loams and clays, and on the sand. I think, less on the wet loams and clays; but cannot say whether most on the sand or chalk.'[73] Soil types all seemed equally affected, making it difficult to find the root cause in the earth. But the presence or absence of barberry shrubs caused tremendous confusion. Estcourt observed: 'We have no barberry bushes in the hedges of this neighbourhood, but occasionally a great deal of mildew.' A farmer in Leeds complicated the question further by observing that barberry seems to thrive on soils subject to mildew anyway; a farmer in Linton observed plenty of mildew and blight but noted that no barberry trees grew in the vicinity, an observation echoed by a farmer in Yorkshire. A farmer in Newmarket, inclined to the geometrical efforts to report outbreaks of rust, reported that he had observed; "'in a line across the field also, issuing out of this semi-circle, the wheat was much injured, but least, furthest from the bush."[74] But in summarizing the reports, Young continued to reject the theory that barberry played a role in spreading crop disease.

Experimentation and Illustrating Evidence

Efforts to utilize print culture to develop a court of public opinion on the question provided opportunities for many people with direct experience of the impact of barberry on wheat cultivation to express their observations. In keeping with the period, as seen above, these observers appealed to geometrical metaphors and analogy to try and represent the veracity of their claims. It is worth noting that the unwillingness to promote the barberry theory was in keeping with the interests of the Board of Agriculture to promote better management and control over seed distribution in the country. John Sinclair believed that rust depended upon infected seed to be spread, and that preparation measures such as steeping could largely eliminate the disease.[75] Sinclair's authority led to his position being echoed decades later in authoritative encyclopedias and popular treatises, such as the widely-read *Penny Magazine*, that steeping wheat in 'certain solutions' virtually eliminates all fungus from crops.[76]

In 1792, Arthur Young included a translation of Felica Fontana's *Osservazioni sopra la Ruggine del Grano,* in the *Annals of Agriculture,* providing British readers with Fontana's argument that rust was, in fact, a parasitic plant.[77] For agricultural writers like Robert Forsyth

(who peddled remedies for various crop and tree diseases to government boards), Fontana had demonstrated that rust was not composed of insect eggs, but rather 'a great multitude of small plants.'[78] Felice Fontana's experiments had a lasting influence on British efforts to understand rust. Joseph Banks, Allen Thompson, and Humphry Davy were all authoritative names that had promoted versions of the plant theory by 1815.[79] The immediate difficulty with such theories was how this parasitical plant – wheat rust—could convey itself to plants the succeeding year, surviving a winter to infect next year's crop. Did the seeds of wheat rust lay dormant in the soil? Did they travel on the wind from warmer climates? Joseph Banks read the responses to Young's circular and corresponded with him on the question of rust, but his own aims were to argue the case of the practical farmer by enlisting microscopes and scientific illustration. He would put the full weight of British science behind the barberry theory.

Botanist on Captain Cook's *Endeavour* voyage and President of the Royal Society, Banks was very interested in developing scientific and experimental agriculture in Britain. He had attended Board of Agriculture meetings throughout the 1790s, and when the Royal Institution was established, Banks worked to position Humphry Davy as its resident chemist and encouraged him to write a series of lectures on agricultural chemistry.[80] As Banks used his status to promote patriotic agriculture, this work had immediate consequences in an era when the cost of bread had soared due to shortages and the continuation of war. And Banks had also accrued experimental success and the taste of political power in questions over Britain's wheat production. In 1789, Banks had been called on by the government to advise on the threat posed by 'Hessian Fly blight' (barley midge), and was instrumental in urging the government to redouble its efforts to catch wheat imports that had evaded quarantine measures.[81] In the course of preparing his work on wheat rust, Banks asked Davy to analyse the nutritional qualities of spring and winter wheat, concluding that winter wheat was more nutritious. After the losses of wheat crops in the early 1800s to disease, Banks corresponded with Arthur Young, Thomas Knight, John Sinclair, and numerous other agriculturalists, as he sought to compile present views and to use his authority as President of the Royal Society to advance a position.[82]

Convinced from his reading of Felice Fontana that these diseases were the product of parasitic fungi (considered plants at the time), Banks discounted the arguments that sought to characterize the attack of insects and fungus as a symptom of a constitutional weakening or degeneration in the plant. Through an acquaintance with the classicist Richard Payne Knight, Banks had established contact with Richard's brother, Thomas Andrew Knight, a farmer in Hertfordshire that Banks would increasingly rely upon for support in furthering his influence in Britain's agricultural and horticultural societies.[83] Knight supported Banks' theory that rust was composed of microscopic, parasitic plants, although he rejected Banks' suggestion that it could be communicated from one species of plant (the barberry) to another.[84] Knight instead suggested that the seeds for rust dwelt in the ground, like those of other fungi and mushrooms. Having examined mushroom spores, he also proposed that infected fields produced the seeds of ruin on an apocalyptic scale:

> I am therefore much inclined to believe that the parasitical fungus, which occasions every disease of this kind, enters the plant, in the first instance, by its roots….a single acre of mildewed wheat would probably afford seeds sufficient to communicate disease to every acre of wheat in the British empire.'[85]

But like others, Banks believed that the task of agricultural science in Britain was to put popular ideas to experimental test, and barberry presented for him an ideal case where

traditional knowledge and understanding could be vindicated by expertise and intervention. Banks made an analogy to mistletoe to try and explain how the parasitic fungus might be capable of living on two different species.[86] How to explain the frequent observations of blight where no barberry shrubs were present? Banks knew from Young's circulars that many farmers and agriculturalists questioned how the theory could be valuable to understanding the causes behind affected fields when there were numerous cases of infection far from any observed plants. Banks speculated that the air could be 'charged with seed for miles together,' but he must have seen that this would provide little motivation for sceptics to admit the possibility that barberry played a role in the injury.[87] He also argued against the degeneration thesis, and perhaps more persuasively than the wind hypothesis, he claimed that 90% of wheat plants grown in a hothouse taken from infected plants grew disease free. If that was a reliable ratio, heredity and infected seed could never be the driving cause behind the malady.[88] We know from the postscript that Banks received considerable criticism for the suggestion that farmers could utilize seed from infected fields—a practice that many would engage in out of necessity anyway, but which nonetheless evidences the political urgency to providing effective advice.[89]

Knight was unconvinced; his own trials in growing wheat near a barberry shrub had resulted in infected wheat, but other wheat fields further away from the barberry were also infected.[90] Banks enlisted Franz Andreas Bauer (1758-1840) to produce illustrations of the parasite, and hoped that the illustrations would provide further evidence of how blight propagated and grew upon its host [Figure 1].[91] Sharing the illustrations Bauer produced with Knight, Banks discovered that the effort to illustrate the theory met with the same resistance as the anecdotal testimony from practicing farmers.[92] The effort to involve the barberry in the explanation of the progress of the disease not only involved a reliance on 'practical farmers', but it also worked against Knight's own beliefs that the causes of most ailments affecting crops were rooted in degeneration, and that the cultivation of new varieties was the most effective means of combatting disease.[93]

Banks was widely criticised for his belief that *Berberis vulgaris* could cause rust outbreaks. A reviewer in the Edinburgh Journal noted that 'a good deal of liberal attack has been excited by these most important suggestions,' not the least because Banks' suggestion that seed from infected fields could be utilized, which the reviewed duly noted would risk 'a considerable portion of the crop' on a lone author's views.[94] 'He has evidently trusted to the commonly received notion…without due inquiry,' complained Aiton, likening the bias against barberry to the charge of witchcraft.[95] In a subsequent survey of the agriculture in Norfolk sponosored by the Board of Agriculture, Arthur Young undertook to interview farmers and gain knowledge of local practice. Young was well aware of Banks's publication, but it clearly had no weight in how he assessed the opinions of the farmers that he met and interviewed. Farmers like 'Mr Margateson' of Norfolk that believed barberry could affect wheat fields were represented as being under the sway of 'observations that could not deceive.'[96] In other words, the farmer was deluded by his own experience. The surveyor visited the parish of Elsing where he learned that local farmers had joined together to extirpate barberry in their area—including on 'the lands of those who are careless in this business.'[97] Agricultural writers persisted in ridiculing Norfolk. The author of a land management guide published shortly after Banks' essay commented that he had 'never perceived the berberry bush produce blights,' but that he understood it was 'a faculty for which the bush of Norfolk may perhaps have obtained an exclusive patent.'[98] In refuting Banks, later writers appealed to division amongst practical farmers to make the case. After all, if practical farmers were considered to form a constitutive body, their disagreement on this point was evidence enough to discredit it. John Henslow took

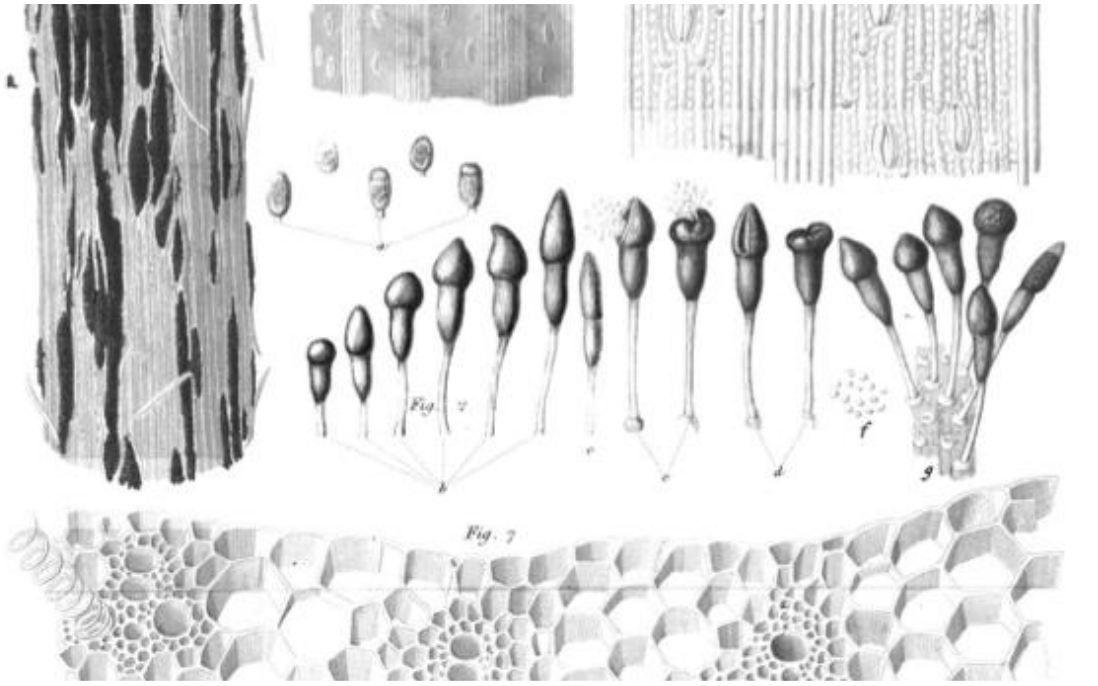
just this approach in 1841. 'Even practical men,' he wrote, 'are by no means unanimous in denouncing the berberry.'[99]

Conclusion

The debates over barberry revealed a deeper epistemological crisis in agricultural science at the close of the eighteenth century. Agriculturalists were not engaged in producing knowledge so much as they were sorting and filtering the good from the bad in the vulgar and practical knowledge of farmers. At the heart of this process was the political claim that Britain's food security was endangered in no small part by the fact that its farmers were unlettered and given to ignorant and contrary practices. There was a strong need to discover points at which practical farmers were not merely using inefficient methods, but where practical farmers were also revealed to be absorbed by superstition and false ideas: barberry presented just such an opportunity.

The history of debates over wheat rust invites comparisons with ideas of citizen science and public involvement in the production of knowledge—yet it is important introduce here some important caveats. The close of the eighteenth century drew questions of citizenship, civic duty, and social order to the fore in Britain.[100] While it is tempting to view the farmers and labourers that held expertise on wheat rust as 'citizens' contributing to science, part of what made this conflict of authority so important was that the agricultural elite were not so eager to view these labourers as citizens, or as contributors to a scientific practice that transcended the boundaries of property and political power.[101] In 1795, the President of the Board of Agriculture, John Sinclair, wrote a satirical story about a kingdom where law, order, and prosperity were all lost when the rural labouring class declared: 'the land is ours, for we till it'.[102] The very right to ownership of the land and its management was tied to the argument that agriculturalists *knew better*—regarding labourers and small farmers as 'citizens' contributing to a larger scientific project would have run against the logic of the arguments made by the Board of Agriculture to support enclosure and increase the powers of wealthy farmers to finance land improvement projects. Sociologists and philosophers interested in citizen science can find in this period that by possessing command of evidence related to pressing scientific questions (like the causes of wheat rust), subjects gained leverage and importance that aided the creation of the very idea of 'citizen.'

Illustrations



[Figure 1: Illustration of wheat rust by Franz Bauer in Joseph Banks, *A Short Account of the Diseases in Corn,* (London: Nicoll 1806).

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