On Social and Political Effects of Plant Pest and Disease Epidemics

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ABSTRACT

Selected historical pest and disease outbreaks in the Old World are discussed in view of their social and political consequences. Large-scale epidemics always caused social unrest, and often hunger, pestilence, and death. When coming on top of deeply rooted and widely spread social unrest such epidemics contributed to political change. Examples are the revolts following epidemics in 1789 and 1846. Epidemics,

regardless of causal and target organisms, have elements in common. The notion of a common concept grew into a firmly established discipline: epidemiology.

Additional keywords: cereal rusts, creeping thistle, ergot, locusts, potato late blight, voles, women scientists.

The history of plant pests and diseases is, at best, hazy. The present-day technical terms did not yet exist in the past. World views then and now hardly share a conceptual basis. The difference between then and now is more than a difference of terminology, hence the term world view. The analytical approach of today is in stark contrast to the holistic view of the past. People communicated in images and symbols (Foucault 1966). The interpretation of these images and symbols seldom is unambiguous (Wilson 2000). Great differences exist between then and now in crop genetics, rotation, tillage, fertilization, pests, and diseases (Ambrosoli 1997; Zadoks 2013).

With this mental reservation, consideration of the historical impact of a few pest and disease outbreaks and epidemics on important social and even political consequences is warranted. This overview hops eclectically through time and space, through three millennia and the Old World.

WHEAT STEM RUST

The fungus (*Puccinia graminis* Pers. f. sp. *tritici*) causes fox-colored eruptions on the green wheat plants. When the wheat ripens, the infested crop does not turn beautifully golden but dreary ashen. The brown eruptions change into hard black pustules. Ash-gray and sooty black. What do these words suggest? Fire!

The Bible book Judges describes the strife between Israelites and Philistines. A thousand years BCE, the area was already rife with trouble. Judge Samson caught 300 foxes, bound their tails pairwise together, placed burning torches between the tails and sent the foxes through the ripening wheat crop of his adversaries (Judges 15:4-5). The wheat caught fire. The black pustules are like the charred remains, whirled down onto the dull gray, broken stems. Telia of stem rust have indeed been found on Samson-era wheat remains in Israel (Kislev 1980). In the Near East, the tale of the foxes, an imaginative way to capture a dreadful and incomprehensible phenomenon in plain words, may have circulated as a folk story (Zadoks 2008).

Changing focus from BCE to the year 1932, from the Near East to the Balkans, we notice a severe epidemic of stem rust appearing, as it were, out of the blue (Savulescu 1953). A severe winter delayed the development of the wheat. The rust had ample time to multiply. The epidemic, most damaging in Romania, fanned out to the west

along the Danube river valley up to Southern Germany and to the north over Ukraine and Russia into Poland and Finland (Zadoks 1965).

At the time, the Soviet regime wanted to establish large state farms and therefore it needed to destroy the peasant farmers, the *kulaks* (Davies and Wheatcroft 2004). This action, in combination with the rash collectivization and mechanization, caused chaos in Soviet agriculture. The seed supply was disrupted and fall sowing was too late. In the south, wheat ripening was delayed, which was good for one extra generation of stem rust and increased yield loss (Zadoks 2008). By coincidence stem rust contributed to the great famine of 1932–33, which caused the death of some five million people (Tauger 2006). Official policy was to spare the town dwellers where possible but country people were severely affected.

LOCUSTS

In 2015, the south of the former Soviet Union suffered a substantial locust plague (see Author-Recommended Internet Resources). Such plagues were all too common historically. The eighth plague of Egypt, some 3,500 years ago, was attributed to locusts (Exodus 10:4-19). In the Bible, the prophet Joel describes the destructive progress of a hopper band pouring down along the hillside—possibly of the Moroccan locust (*Dociostaurus maroccanus* Tünberg) (Joel 2:2-3).

The desert locust (*Schistocerca gregaria* Forsk.), which needs rainy periods in dry breeding grounds, caused havoc in North Africa in 125 BCE. An estimated 800,000 deaths followed due to hunger and pestilence (Schlesinger 1967). The European locust (*Locusta migratoria* L.), today rather innocent, is said to require dry periods in its wet breeding grounds, primarily the river deltas around the Black Sea. The year 873 was calamitous. Like the stem rust, the locusts followed the Danube flyway. They appeared in Western Europe in big swarms that darkened the sun, 2 months long: celestial ‘fire dragons’ (Delort 1984; Leguay 2005). The Frisians, living in the north of the Netherlands, were appalled when they saw these animals thick as a thumb and with ‘six’ wings (Steenstra 1843). Angels are known to have two wings, cherubs four, and seraphins six (Isaiah 6:2). Diabolic seraphins they were, eating everything green, with famine and pestilence in their wake.

Europe suffered many locust plagues (Cramer 2007). The pattern is clear. Everything green is eaten, with the exception of fir needles. Large-scale aid was impossible, the cattle died due to lack of food,

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and the people died from hunger and infectious disease. Locust plagues caused social unrest, confusion, fear, riot, and plunder but as far as we know, mainly at the local level.

ERGOT

A fungus (*Claviceps purpurea* (Fr.) Tull.) that transforms the rye kernel into an ergot, a poisonous, large, black body. The poison, ingested by eating bread made from poorly cleaned rye, caused a gangrenous form in which body parts drop off without bleeding. In the Middle Ages, ergot thus contributed to a multitude of mutilated beggars and clowns (Barger 1931).

The ingestion also had a convulsive form that caused spasms and delusions. The spasms were known as Saint Vitus dance, the dancing mania of large groups of people jumping and dancing in trance until they fell down from exhaustion. The first large outbreak on record occurred in the German town of Aachen (Aix-la-Chapelle) in 1374 (Barger 1931). Village populations sometimes were rendered delusional. A plant disease thus contributed to the many witch processes in the sixteenth and seventeenth centuries, social disturbances, and sudden communal conversions to a stricter faith in the eighteenth century (Haarmann et al. 2009; Matossian 1989).

The relationship between Russia and Turkey was not always friendly. Russian Orthodox Tsar Peter the Great developed a stratagem to defeat the Muslim Ottoman Empire. In 1722, he raised a large army near the Caspian Sea, at the mouth of the river Volga. Soldiers and horses were fed with rye. Then, things went terribly wrong. Most of the horses died and countless soldiers were mutilated by ergot in the rye (Barger 1931). The grand scheme failed hopelessly. The defeat of the Turks became a political nonevent.

Moving from Russia to France, but sticking to the eighteenth century, we go from a nonevent to a top-event. The French grain harvest of 1788 was a failure and, to make things worse, the winter 1788–89 was bitterly cold. In 1789, the country folks went hungry. Bands of thugs stole from the standing crop. People ate ergot-infested immature rye that summer. Delusions once more. Then, a sudden panic beset the people, a panic that spread over France like an epidemic: *la Grande Peur*, that is “the Big Fear.” Landowners, afraid of the mob, congregated in Versailles. The *Ancien Régime*, the “Old Regime,” was abjured with the “Tennis Court Oath,” June 20th, 1789. Thus, the French Revolution of 1789 was sparked off, not due to ergot but certainly not without the political contribution of this plant disease (Matossian 1989).

VOLES

Outbreaks of voles occurred frequently and in many regions. The Bible book Samuel describes a plague of voles intended to punish the Philistines, who had stolen the Ark of the Covenant from the Israelites (1 Samuel 6:4-5). The debt was bought off with five golden mice. Voles boosted religious and political problems over 3,100 years ago.

In the Netherlands, a serious outbreak of voles appeared around the *Zuiderzee* (today Lake IJssel) following the dry summer of 1596 (Van Ingen 1620; Velius and Centen 1740). Pastures, crops, and stocks suffered great damage. Voles were controlled by catching them in “mice pots” (Van der Kamp 2010; Velius and Centen 1740). The record was set at 2,300 animals caught in one night around a single haystack (Van der Poel 1977).

Toward the end of 2014, the famous Frisian pastures, in the north of the Netherlands, were devastated by voles (among others, *Microtus arvalis* Pallas), quite a surprise because good farm hygiene and heavy mechanization should have kept the voles down. These little animals, however, multiply rapidly, a fact revealed by Aristotle in the fourth century BCE (Louis 1964). He noticed that a severe plague developed within months and collapsed rapidly due to rain, cold, and disease. Weather and war conditions induced outbreaks of

voles (1914, 1918), which contributed to the anguish of Imperial Germany during World War I (Schwarz 1919; Zadoks 2008).

STRIPE RUST OF RYE

Who has ever heard of stripe rust on rye, *Puccinia striiformis* Westend. f. sp. *secalis*? It is gone today but it was once a dangerous disease, as in the year 1846 (Zadoks 2008). It takes a year to build a real epidemic of stripe rust (Zadoks 1961). In the foregoing year, the amount of rust must increase sufficiently to infect the self-sown rye in the stubble. A cool wet summer is needed to delay the harvest, to cause many self-sown volunteer plants, and to supply moisture for the benefit of the oversummering rust. The newly sown winter rye is infected and a mild winter guarantees a steady multiplication of the rust. Then, nothing can stop the epidemic.

The 1846 epidemic followed this pattern exactly. The epidemic was Europe-wide, from Belgium and the Netherlands in the West over Germany into Poland in the East. Wide-spread failure of the rye crop added to the dearth due to the loss of the European potato crop (see below). Remember that only the well-to-do ate wheaten bread, the commoners had to chew rye bread.

CREEPING THISTLE

In former times, before the herbicide era, weeds were the farmers’ worst enemy. In the Middle Ages especially, the creeping thistle (*Cirsium arvense* (L.) Scop.) was a real problem (Zadoks 2013). In England, thistles were pulled up by hand, and the hand was protected by a heavy leather glove. More elegant was “head hunting” because the laborer could work upright. The thistle stem is blocked by means of a fork on a stick and the thistle head is cut off by means of a pruning knife, mounted again on a stick. Timing was all: Saint John, June 24. Cut earlier, every beheaded plant would produce three new ones; cut too late, the plant would set seed and reproduce dramatically (Mane 2006). The feast of Saint John the Baptist was the midsummer festival in the Middle Ages (Dugan 2015).

The writings by the chief-shepherd of the French King Charles V suggested a more ecological thistle control in 1379 (Carroll and Wilson 2012). The sheep grazed the grain stubble field, ate the thistles and dropped the digested thistles as excrements on the field, manure for the next crop of corn (Mane and Wilmart 2011).

Thistles were so problematic that thistle beheading became a symbol for the month of June, drawn in books and sculpted in churches, an admonition for rich and poor, with a spiritual effect at best, certainly an economic problem, but without known political consequences.

POTATO LATE BLIGHT

Potato late blight (*Phytophthora infestans* (Mont.) de Bary) was introduced into Belgium with new samples of potato varieties from the United States in 1844 (Bourson 1845). In that year, a minor epidemic developed in Belgium and adjacent areas (Zadoks 2008). A devastating epidemic occurred the following year in England and Ireland. On the Continent, the year of disaster, however, was 1846. The blight hit the potato crop hard, from Ireland to Romania, from Scotland to Portugal. If the crop did not pine away in the field, the tubers would rot in storage.

The two starch crops, rye and potato, the energy supply of the commoner, failed miserably in 1846 due to stripe rust and late blight, respectively. The sequel was a famine with about 700,000 dead, called the “Continental Famine.” Its consequences were comparable to those of the better known “Irish Famine” (Ó-Gráda 1989). On the Continent, a million people left their homes, migrants in search of a new and better future in Europe. In the aftermath of the famine, another million or more, from the German states mainly, adventured to the Americas (Maxeiner et al. 1988). Poverty and hunger led to a revolution in Paris, 22 February 1848, followed by

uprisings in many capitals of Europe. Political consequences could not fail to occur, as exemplified by the Netherlands.

Even the Netherlands, then a rather sleepy nation, had its row, 24 March 1848, in dull Amsterdam. King William II, an absolute ruler, got worried about all the unrest and requested a Mr. Thorbecke, Member of Parliament, to draft a new and democratic Constitution. In the Netherlands, the present form of government is rooted in the Constitution of 1848, with thanks to stripe rust of rye and late blight of potato (Van der Heijden 2004).

The misery of the country folk deeply impressed the German village Mayor Raiffeisen, himself a farmer's son. He founded a mutual fund to provide his pauperized farmers with some money—today we would say microcredit—to buy a little seed, or a cow (Maxeiner et al. 1988). This fund was the beginning of a system of cooperative banks all over Northwestern Europe. The large and flourishing Dutch RABO-Bank—the RA still referring to Raiffeisen—is a proud example, with thanks again to rye rust and potato blight.

The devastating power of potato late blight slackened in the second half of the 19th century but in the early 20th century, the disease showed its political power once more. During World War I (1914 to 1918), Germany's grain supply from overseas was cut off by a naval blockade; the food situation became precarious. In 1916, the weather in Germany was so cool and wet that a severe outbreak of potato late blight occurred (Zadoks 2008). It could have been kept in check by spraying Bordeaux mixture, but the necessary copper was scarce and it was used for bullets rather than for disease control (Cramer 2007).

Half of the potato stock was lost by rotting away, the losses being aggravated by obvious mismanagement. During the severe winter of 1916–17, the people had to eat swine fodder, swedes (*Brassica napobrassica* (L.) Mill). That winter is still remembered as the *Steckrübenwinter*, the “Swedes Winter.” The blockade, assisted by *P. infestans*, killed over 750,000 persons in Imperial Germany (Vocke 1984). In the Austro-Hungarian Empire, even more people succumbed (Zadoks 2008); soldiers deserted the army in great numbers (Rauchensteiner 1993). In Germany, the year 1917 was a year of protests with riots and local disturbances. The German soldiers at the front, worried about the hunger at home, lost their *Wille zum Krieg*, their fighting spirit. The Allied Forces won the First World War certainly not due to but indeed with the unsolicited help of the potato late blight.

DISTRESS AND RELIEF

Sometimes, though rarely, history is not determined by kings and emperors, nor by politicians, but is shaped, at least in part, by plant pests and diseases. In such cases, outbreaks of plant pests and diseases require a preparatory period, in the order of a year, with a characteristic sequence of specific weather types. These outbreaks cause human distress and social unrest but they have political consequences only when adding to already smoldering unrest due to deeper socio-economic causes.

Epidemics could not be halted. What about people in dire misery? Local charity often tried to alleviate human suffering but charity was hopelessly inadequate to relieve the population at large. Institutional support at the national scale did not yet exist. Fortunately, today national and international institutions are in place to predict, monitor, or control epidemics and to relieve human misery by food aid and medical support.

INSTITUTION BUILDING

History is a complex tissue of numerous interwoven threads. Here I pull one thread from the fabric, a thin and sinuous thread. The Netherlands were, and are, flower bulb country. Around 1880 an outbreak of yellow disease in hyacinths (*Xanthomonas campestris* (Pammel) Dowson pv. *hyacinthi*) threatened the business. It became

a cause to create the private Foundation “The Willie Commelin Scholten Phytopathology Laboratory” (WCS), Amsterdam, 1894 (Faasse 2008). J. Ritzema Bos, its first director, had attended the 1990 International Congress of Agriculture and Forestry in Vienna, where he became a member of the new International Phytopathological Committee. In 1891, Dutch committee members founded the world's first national phytopathological society (Horsten 2016). Anxiety over a possible epidemic of the San José scale (*Quadraspidiotus perniciosus* (Comstock)) on Dutch ornamental trees, an export product, sent Ritzema Bos to California, 1898. The mission resulted in the establishment of a national plant protection service in 1899. Vienna decisions led to an International Institute of Agriculture, opened in Rome, 1908, to document production statistics and crop losses. This institute was a predecessor of the United Nations Food and Agriculture Organization (FAO), chartered in 1945 and again located in Rome. FAO plays a prominent role in international plant protection politics.

Exactly one hundred years ago, 1917, the Netherlands welcomed their first female university professor, Johanna Westerdijk, the second director of WCS. She literally embodied the notion that women could find a rewarding career in science, at the time a social innovation of importance (Zadoks and van Bruggen 2008). The epidemic of Dutch elm disease (*Ophiostoma ulmi* (Buisman) Nannf.), first noticed in 1910, severely mutilated many cityscapes and landscapes in North West Europe and North America. It posed an enigma deciphered largely by women scientists (Holmes and Heybroek 1990), under the inspired guidance of Westerdijk. The fungus reference collection set up by Westerdijk in 1904 survived the demise of WCS (Faasse 2008) under the new name of “Westerdijk Fungal Biodiversity Institute,” with over 100,000 accessions (KNAW 2017).

FROM EPIDEMICS TO EPIDEMIOLOGY

Humankind has experienced many epidemics over the last three millennia, regardless of the causal and target organisms. But when did the idea that these phenomena, scattered over time and space, had something in common originate? The notion that these diverse events could be captured in a common concept called “epidemiology” developed over the centuries (Zadoks 1976).

Around 400 BCE, the medical practitioner Hippocrates of Kos coined the word “*epidemios*,” meaning “what is upon the people” and used as noun and adjective. One of his books is ‘Of epidemics’ (Jones 1972), in which he described an epidemic and many individual cases of illness. The word “epidemic” appeared in the title “*Libellus de epidemia*” meaning “Booklet on the epidemic,” written by Niccolò da Lonigo or Leonicensio in 1497 (Castiglione and Krumbhaar 1975; Leonicensio 1497). ‘The epidemic’ was the syphilis epidemic raging over Europe shortly after the discovery of America. Parkin (1873) used the word “epidemiology” in the title of his book on *Epidemiology: Or the Remote Cause of Epidemic Diseases in the Animal and in the Vegetable Creation*. Epidemiology as a medical discipline became firmly established in 1874 by the founding of the journal *Allgemeine Zeitschrift für Epidemiologie* (*General Journal for Epidemiology*) in Germany.

In the botanical area, the adjective “epidemic” appeared in Duhamel du Monceau (1728), who studied an epidemic of a soilborne disease of saffron crocus and devised methods of control. In 1833, the medical doctor Unger applied the word “epiphytotic” to an epidemic on plants (Unger 1833). Von Martius (1842) used the substantive “epidemic” in the title of his book on potato dry rot caused by *Fusarium* spp. In these instances, the word epidemic was used in a modern sense. However, using the word epidemic in botany does not necessarily create the discipline of botanical epidemiology.

The need for such a discipline is clear from a remark by Smith (1866): “Strictly speaking, however, all that we really know is this – that when certain conditions exist, epidemics break out and spread;

that where those conditions do not exist, epidemics do not break out and spread; and that where those conditions exist, but have been removed, there-upon epidemics cease.” Of course, ideas and actions now often ranked under the heading of epidemiology have been developed over time as in plant quarantine and disease warning. Gäumann (1946) published a systematic treatise on the principles of plant infection with a largely ecological approach. My favorite quote: “Every epidemic develops according to its own rules, changes its character, expands and becomes malignant, decreases and becomes milder: it has an appearance of its own, its morphology, its own genius epidemicus.” Then came Vanderplank (1963) with his epochal book *Plant Diseases: Epidemics and Control*. His definition: “Epidemiology is the science of disease in populations.” Vanderplank firmly rooted epidemiology in genetics, mathematics, and agriculture.

The final question is “if and how” epidemics as those exemplified above affected the discipline of botanical epidemiology. The potato late blight epidemics of the 1840s sparked off a flurry of scientific papers but these did not create a discipline. The Swiss Gäumann was a generalist of very high standing; Vanderplank set out as a potato breeder in South Africa. These two Founding Fathers were thinkers. They worked in the main stream of plant pathology but they had the ability to step aside and to look at certain phenomena with a distant eye, to abstract and to conceptualize, and thus they firmly grounded the discipline of plant disease epidemiology as a distinct branch of science.

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AUTHOR-RECOMMENDED INTERNET RESOURCES

Time Magazine: <http://time.com/3985163/russia-locusts-farmlands-crops-devastation>

CNN: <http://edition.cnn.com/2015/08/04/europe/russia-locust-swarms>