

Johanna Westerdijk (1881–1961) – the impact of the grand lady of phytopathology in the Netherlands from 1917 to 2017

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Abstract One century ago, on February 10, 1917, Johanna Westerdijk delivered her inaugural speech at Utrecht University entitled “New directions in phytopathological research”. By doing so, she became the very first female professor in the Netherlands and set the stage for many female professors who followed her example. Besides her remarkable performance as a role model for women in science, Johanna Westerdijk was also a pioneer in the global science field of phytopathology, which rapidly emerged at the end of the 19th century and reached maturity during the course of her scientific career.

The start of phytopathology

Since the beginning of agriculture more than 10,000 years ago, a narrow range of plant species was cultivated for food production. Early crop varieties with

improved yields and without toxic compounds were selected for human consumption. Because the selected crops were grown in monoculture, these agricultural systems were particularly prone to infections by plant pathogens. From the earliest written sources in history to reports in the mid-nineteenth century, crop yield losses and famines caused by plant diseases were reported in all regions in the world, without knowing the nature of their causal agents (Zadoks 2013).

In the 2nd half of the nineteenth century the first plant diseases were recognized as being caused by alien organisms (Kühn 1858). Various organisms were found as causative agents of plant diseases and Phytopathology as scientific discipline was born. Rapid progress in taxonomy and epidemiology, and the increased awareness of host specificity of plant pathogens, led to the first attempts to control plant diseases with an-organic pesticides. This innovation at the end of the nineteenth century was a prelude to crop protection strategies that we know today.

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Early phytopathology research and application in the Netherlands

Dutch scientists were at the frontier of this new scientific discipline. An important pioneer was Dr. Jan Ritzema Bos, teacher at the Wageningen Agricultural College since 1873. Ritzema Bos performed research in close collaboration with farmers, as he strongly believed that the new discipline of phytopathology was an applied science field that could help farmers to control diseases in their crops.

Together with the famous Dutch plant geneticist Prof. Hugo de Vries from the University of Amsterdam, he attended the first international congress on Agriculture and Forestry in 1890 in Vienna. This meeting was organised by experts including Prof. Jacob Eriksson from Sweden, who strived for more international collaboration between phytopathologists worldwide. During this meeting, an International Phytopathology Committee was founded and all participants agreed to establish a National Section in their own country to promote international collaboration in the field of phytopathology. After returning home, Ritzema Bos and de Vries immediately laid the foundation for this National Section by inviting not only scientists but also advisors, farming organisations, and policy makers for an inaugural meeting. On April 11, 1891 the Netherlands Society of Plant Pathology was established. As this society was the first to comply with the Vienna agreement, it is the oldest phytopathological society in the world. In 2016 the now Royal Society (in Dutch: “*Koninklijke Nederlandse Plantenziektkundige Vereniging*” (KNPV)) celebrated its 125 years anniversary (Horsten 2016).

As a follow-up of the Vienna meeting, de Vries started to lobby for the foundation of a phytopathology institute, in order to support the rapidly modernising and economically important sectors of agriculture and horticulture. However, it turned out to be difficult to convince the government to provide funding for such a forward-thinking initiative. Although for a sad reason, a public-private funding source ‘avant la lettre’ brought a solution. Willie Commelin Scholten, a biology student at the University of Amsterdam supervised by Prof. de Vries, suddenly passed away. His father, a fortunate Amsterdam trader, wanted to support phytopathology research to commemorate his son, and on the advice of de Vries he decided to finance a new institute. The Willie Commelin Scholten (WCS) Phytopathology Laboratory was established in 1894 in Amsterdam. As he was the foremost Dutch expert on phytopathology, Ritzema Bos moved from Wageningen to Amsterdam to become the first director of the new WCS laboratory, and to be appointed at the University of Amsterdam as the first professor in phytopathology in the Netherlands in 1895. Because he strongly believed in an applied strategy, he developed the WCS laboratory into a phytopathological inspection service, where farmers brought in diseased plant material and the research staff performed diagnostics. Ritzema Bos did not publish the results in scientific journals but as information sheets to advise farmers. He also served as president of the

KNPV from 1895 until 1928, and used the society’s journal ‘*Tijdschrift over Plantenziekten*’ to publish hundreds of applied notes over the years. De Vries, and his former student Frits Went, since 1896 professor in general botany at the University of Utrecht, and who had replaced him as a board member of the WCS Laboratory, saw that their original plan had failed; at the new institute fundamental research in the field of phytopathology did not get off the ground. So, when in 1904 the government decided to upgrade the Agricultural College in Wageningen to an Agricultural University of Applied Sciences (upgraded in 1918 again to an Agricultural University), they convinced Ritzema Bos that a position for him in the new Wageningen academic world would fit him better. In 1905, Ritzema Bos moved back to Wageningen to become director of the newly established Institute for Phytopathology (Horsten 2016; Faasse 2008).

The central role of Johanna Westerdijk in Dutch phytopathological research

De Vries and Went needed to hire a successor for Ritzema Bos. As more applied research had been moved to Wageningen together with its major advocate Ritzema Bos, they had now their hands free to appoint a director with more interest in fundamental research. They had their eye on a young female scientist, a former student of de Vries, who had just finished her doctorate (*cum laude*) at the University of Zürich, (Switzerland) on the physiology of mosses. Because of the limited research facilities and low salary (Zadoks and Van Bruggen 2008) the position was apparently not very attractive to more senior male candidates, and as a result the 23-year-old Johanna Westerdijk was appointed in 1906 as the director of the WCS laboratory in Amsterdam. With her international education - she spoke French, German, English and Dutch fluently - her energy and intellect, broad scientific interests, and people-management skills, Westerdijk was able to hire good collaborators and to convert research within the institute into a more fundamental direction. Went asked Westerdijk to take care of his fungal collections which was the start of a centralized international collection entrusted by the ‘Association Internationale des Botanists’ under her supervision. The Central Bureau of Fungal Cultures (in Dutch “*Centraal Bureau voor Schimmelcultures*” (CBS)) was founded in 1907 and Westerdijk was appointed as the director. In the years to follow, Westerdijk as director of both the WCS Phytopathology Laboratory and the CBS,

impressed with her fundamental research on plant diseases and fungi. Her work did not remain unnoticed and in 1917 at the age of 34 she became professor in phytopathology at the University of Utrecht - the very first female professor in the Netherlands. Thirteen years later, in 1930 she was also appointed as professor in phytopathology at the University of Amsterdam on the chair originally created for Ritzema Bos. Westerdijk held the two director- and professorships until her retirement in 1952. As the growing WCS Laboratory needed more space which could not be offered by the University of Amsterdam, Went suggested a grand villa in a spacious park in the village of Baarn, owned by the University of Utrecht. It took some debate in Amsterdam, but when the University of Utrecht offered co-financing the decision was made. Westerdijk, with the WCS laboratory and the CBS, was very happy to move to Baarn at the end of 1920, heading from now on a joint institute of the universities of Utrecht and Amsterdam. The history of this institute and its inhabitants (many female scientists) is beautifully described in the book 'In Splendid Isolation' (Faasse 2008) and in the biography of Johanna Westerdijk (Faasse 2013).

Westerdijk's major scientific achievement: the female force to fight the Dutch elm disease

In this short overview we focus on the important scientific contributions of Johanna Westerdijk during her long scientific career (1906–1952), and the achievements of her co-workers (many of which were female). At the WCS laboratory she built a team of excellent scientists, with a strong focus on fungal diseases. At the same time, she laid the foundation for the CBS and extended it to a centre of excellence with one of the largest collections of fungi, yeasts, and bacteria in the world.

She started with the practical line of research that Ritzema Bos left behind. She diagnosed *Phoma betea* as the causal agent of damping-off in sugar beets and published an advice report for farmers as a first in a knowledge extension sequence. She was interested in fundamental research with an applied target, but probably started with this more applied project to prove her predecessor Ritzema Bos wrong with his remarks expressing his doubts that 'this lady would be able to take on his former tasks' (see refs in Zadoks and Van Bruggen 2008).

The most important fundamental breakthrough was her research on the Dutch elm disease, (Holmes and Heybroek 1990). When the disease was first noticed in 1919, the

young professor Westerdijk adopted it for in depth scientific study. The approach to focus on a single disease was rather new for that era. In a period of several decades, a number of key female scientists joined her institute to work on this wilting disease in elms. The indication 'Dutch' does not mean that it is a Dutch disease, but rather to honour the Dutch scientists of Westerdijk's group for unravelling many aspects of this disease. Westerdijk pioneered in crowd funding: she collected funds for her scientific research from 996 municipalities in the Netherlands, who all were interested in preventing their elms from becoming infected.

The first female scientist who started to collaborate with Westerdijk on the Dutch elm disease was Barendina ('Dina') Spierenburg in 1919. Spierenburg was appointed at the newly established Plant Protection Service in Wageningen (again with Ritzema Bos as director) and worked closely together with Marie Beatrice Schwarz, the first scientific assistant of Westerdijk in the WCS laboratory at the new location in Baarn. Spierenburg showed that the disease caused a real epidemic among lined elms along streets in many areas of the Netherlands. She recognized the causative pathogen, but was not yet able to confirm the disease cycle. Schwarz, preparing a PhD-thesis, used Westerdijk's fungal culture collection to perform inoculation studies on elm trees and discovered that the fungus *Graphium ulmi* caused the disease. For about a decade there was controversy among international phytopathologists (mostly male) whether Schwarz as a young inexperienced student could have really discovered the causal agent of the devastating tree pathogen. As Schwarz left for Indonesia after her PhD exam in 1922, and quitted research because she got married (which was usual in those days), she was no longer in a position to convince the phytopathology society. Another female graduate student of Westerdijk, Christine Buisman, repeated the experiments of Schwarz and was able to experimentally proof that Schwarz was right; *Graphium ulmi* (later renamed in *Ophiostoma novo-ulmi*) was the causal agent of the Dutch elm disease. Buisman's scientific career was very promising. Within a few years she was well recognized, conducted her studies in international collaboration (e.g. she confirmed the first findings of the Dutch elm disease in the American Midwest), and published a large number of scientific papers. Unfortunately, she died tragically in 1936, too young to harvest the full potential of her bright mind. In the meantime, Westerdijk had appointed another female doctoral candidate, Maria Ledebor, to study the physiology of the causative fungus and to find means to control it. She found for the first time a potential

chemotherapy which, after injection of diseased trees, inhibited further spread of the infection. However, phytotoxicity of the chemical agent prevented a further applied development of this control method. In 1936 another female staff member of Westerdijk, Dr. Johanna Went, successfully started a breeding program for resistance in elm trees. This program ran for more than five decades and resulted in various more or less resistant clones that were multiplied by the nursery industry and planted throughout the country. Today we can still enjoy these healthy elms in our towns and rural landscapes.

After the retirement of Westerdijk in 1952, the new director of the WCS laboratory, Prof. Louise Kerling, continued the fundamental work on the Dutch elm disease, (Kerling et al. 1986). An important result was the finding of a ‘vaccine’ comprised of spores of *Verticillium albo-atrum*. Since the eighties of last century, further development and improvement of this vaccine resulted in a product applicable in practice. It is interesting to note that the Molecular Plant Pathology laboratory of the University of Amsterdam, the ‘Amsterdam’-branch of the former WCS laboratory in Baarn, together with an industrial partner (now known as BTL Bomendienst) commercialized the product under the brand name Dutch Trig®. Since 1992 Dutch Trig® is injected in elm trees to immunize them against the Dutch elm disease, initially in the Netherlands only, but nowadays in many other countries as well. At the end of the twentieth century the vaccine production was taken over by Wageningen University and Research. Not only our elm trees benefit every year from the innovative research started by Westerdijk 100 years ago, but also the collaboration between the phytopathology groups of Amsterdam, Utrecht and ...Wageningen!

Westerdijk’s other scientific achievements

Westerdijk had a broad scientific interest in a variety of diseases of practical importance. She transformed research from descriptive - which was common in those days - towards a more experimental approach. Next to all experimental research on Dutch elm disease, she and her team performed elegant experimental research on a mosaic disease in tomato. By using filtered plant extract, she showed that the disease could not be caused by bacteria or fungi but by a novel virus. Other co-workers studied fungal diseases and mechanisms of fungicides in a variety of crops with always in mind to find a solution for a practical problem by exploiting a

scientific and experimental approach (see refs in Kerling et al. 1986; Zadoks and Van Bruggen 2008).

As a young student, Westerdijk was already internationally oriented as she studied in Switzerland and Germany. In 1913 she travelled to colonial Indonesia to study fungal diseases in plantation crops and to establish collaborations, and in 1915 she visited the United States and started a collaboration with the US Department of Agriculture. As a few of her students were from South Africa, she visited this country in 1938 for the first time, which led to life-long warm relationships with South African scientists, who very often became her personal friends.

Westerdijk had very good organizing skills. By clever lobbying she managed the transfer of the WCS laboratory and the CBS in 1921 from the small location in Amsterdam to a spacious villa with experimental fields in Baarn. She developed the fungal culture collection of the CBS into the largest fungal collection in the world, with an outstanding international visibility. In 1907 Westerdijk started with a collection of 50 cultures, donated by Went. At her retirement the CBS collection comprised nearly 9000 cultures. During her entire career, she was able to recruit very talented students and staff to her laboratory who performed pioneering work on many fungal diseases. She was also – as we call it now – an excellent people manager, as exemplified by her motto ‘*Werken en feesten vormt schone geesten*’ (‘For fine minds, the art is, to mix work and parties’) engraved above the entrance of her institute. She lived in the villa in an apartment and considered work and private time to be coupled, to get the best out of both. She loved to organize parties with her staff, or music evenings (she played the piano), own theatre productions or humorous cabaret performances after successful PhD defences, in which she liked to play a comic role. Her humour when encouraging students, her loud laugh and praise when an experiment was successful, and her spirit to jointly perform excellent research, constructed a unique bond between staff and students (Faasse 2008). Internationally her organizing talents were appreciated as well. She was cofounder of the (Royal) Netherlands Mycological Society in 1908, president of the International Federation of University Women (1932), and president of the (Royal) Netherlands Phytopathology Society, KNPV (1945). Westerdijk has been rewarded with many honorary doctor’s degrees, honorary memberships of international scientific societies, and royal orders (Faasse 2013).

Westerdijk's legacy

After her retirement in 1952 Johanna Westerdijk continued living in her apartment at the institute in Baarn. She withdrew completely from her former professional duties and was very keen not to be in the way of her successor. But she continued to have warm contacts with her former students, staff and international visitors. When she died in 1961 hundreds of people attended her funeral. Her legacy is enormous for the dawn of the research field of phytopathology in the Netherlands, and for being a role model for her students and for both, female and male academics.

She was the founder of a strong experimental approach of various long lasting research lines, still existing today.

In the time that it was not easy for girls to start an academic study, let alone a career in academia, she was appointed in 2017 as the first female professor in The Netherlands. By her courage and her academic achievements, she became a role model for female academics. Not only in those days, but also today as seen by political and media attention at the many festivities held in 2017, to commemorate 100 year professor Westerdijk.

She was a very skilled organiser of WCS and CBS. In 1992, 40 years after Westerdijk's retirement, the research institute in Baarn was closed. However, the research continued in the Phytopathology chair group at Utrecht University (headed by Prof. Kees van Loon, who was succeeded in 2006 by Prof. Corné Pieterse), and the Molecular Plant Pathology group at the University of Amsterdam (headed by Prof. Ben J.C. Cornelissen, who was succeeded in 2018 by Prof. Martijn Rep). The CBS moved to the Utrecht Science Park and continued to grow in a world-wide centre of excellence on fungal biodiversity, headed by director Prof. Pedro W. Crous. In 2017 the CBS was renamed into Westerdijk Fungal Biodiversity Institute, to commemorate the legacy of Johanna Westerdijk.

During her impressive career, Westerdijk supervised 56 PhD students, almost half of which were women. Many of her students dispersed around the globe to set-up their own research and teaching programs the way Westerdijk did.

After her retirement in 1952 she established and financed the 'Johanna Westerdijk Foundation' to support travel, exchange and internships of young

phytopathology students or researchers to acquire scientific knowledge abroad.

After more than 100 years, Westerdijk's legacy is still alive, and this is shown by this special issue of EJPP. On the cover of this special issue, the academic legacy tree of Johanna Westerdijk is visualized. In an introductory article, Westerdijk's biographer, Patricia Faasse, highlights some interesting characteristics and achievements of the members of the legacy tree. Moreover, this special issue showcases a series of scientific articles of female scientists, who followed in the footsteps of Johanna Westerdijk in the Dutch phytopathology research arena.

With this special issue of EJPP we aim to commemorate the enormous importance of Johanna Westerdijk for the scientific dawn and progress of phytopathology in the Netherlands and abroad, and for being a role model as the first female professor in the Netherlands. We hope that you as scientist will be inspired by her, when reading this special issue of EJPP 'Johanna Westerdijk 1917 – 2017'.

Compliance with ethical standards

Conflict of interest The authors P.M.B., C.M.J.P., F.G., and B.J.C.C. declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by the authors.

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