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Professor Kerling, her life and work

A. J. P. OORT and J. G. TEN HOUTEN

Laboratorium voor Fytopathologie, Landbouwhogeschool, Wageningen
Instituut voor Planteziektenkundig Onderzoek (IPO), Wageningen

Louise Catharina Petronella Kerling ("Loes" to her friends) was born in The Hague on July 19, 1900. After finishing secondary school she started her studies in biology at the University of Leiden and in 1925 passed the "doctoraal" examination with botany as her principal subject. In 1922, she had already been appointed assistant in the botany department and she continued in this post, after her final examination, until November 1926. During the summer vacations she often worked at the "Plantenziektenkundige Dienst" (Plant Protection Service) at Wageningen, where she met van Poeteren, Schoevers and Dina Spierenburg. One summer she worked, under the guidance of Quanjer, at what was then the "Laboratorium voor Mycologie en Aardappelonderzoek", Wageningen. Thus, while still a student, she had already shown a keen interest in plant pathology and the agricultural centre of Wageningen. This led her to look for a job at Wageningen. The only post vacant at the time was one taking care of rats at the "Plantenziektenkundige Dienst", but for obvious reasons this was not very attractive to her. Fortunately another possibility soon arose: an assistantship in the Botany Department of the Agricultural University. She accepted this post with enthusiasm and started work in November 1926. In Reinders' laboratory her knowledge of anatomy and morphology was greatly extended and her interest in these sections of botany was highly stimulated. This interest did not flag during her later career, as became apparent many times in her research and publications. In order to satisfy her manifest interest in plant pathology Reinders suggested that she should ask Johanna Westerdijk for a subject for a doctoral thesis. On Westerdijk's advice she started a study on the anatomical structure of leaf spots and for her work on this subject she obtained het doctor's degree on July 2, 1928 at Utrecht. Kerling stayed at Wageningen for another year, but left in June 1929 to take up a post as a teacher at a secondary school ("Gouvernements Algemeene Middelbare School") at Jogjakarta, Java (1929–1935).

After a year's leave of absence in The Netherlands she returned to the Indies, first as a teacher at the secondary school ("HBS") at Medan, Sumatra (1936–1939) and later again at Jogjakarta. In 1942 she had to give up this post for the school was closed as a result of the Japanese occupation. Without means of subsistence Kerling's prospects were none too promising, but fortunately, through the mediation of Thung, who was working there at the time, she got an appointment at the "Algemeen Proefstation voor de Landbouw" at Buitenzorg, Java. Only one year later she was interned in "Kamp Halmaheira" at Semarang. During her internment, which lasted well over two years, Kerling contributed greatly towards keeping up the spirits and morale of the camp population, including teaching and lecturing. She also carried out some investigations on dysentery at the medical laboratory.

After the liberation at the end of August 1945 Kerling – ill and weak, as were so many others – was nursed in hospital for a few months, and later evacuated to Australia for further recovery. Thanks to her great will power and strong constitution recovery proceeded fast so that during the last months of her stay she was able to work as a guest in the plant pathology laboratory at the Waite Agricultural Research Institute, Adelaide. While still in Australia she was invited by Quanjer to join the staff as a plant pathologist at the "Laboratorium voor Mycologie en Aardappelonderzoek", now the "Laboratorium voor Fytopathologie" of the Agricultural University at Wageningen. For more than six years Kerling gave the practical courses for advanced students and carried out research. In 1952, when Johanna Westerdijk retired, Kerling was called to fill the vacancies of extraordinary professor at the Universities of Utrecht and Amsterdam and to undertake the directorship of the "Phytopathologisch Laboratorium Willie Commelin Scholten" at Baarn. From Novemver 1, 1952 onwards she continued to hold these positions.

In her chequered life four periods can be clearly distinguished: the period of her University studies with the assistantship at Leiden and her three years at Wageningen (1926–1929); the period spent in the Dutch East Indies (1929–1945); the second Wageningen period (1946–1952), and the fourth period, when she was Director at the Baarn laboratory, with the two professorships at Utrecht and Amsterdam (1952–1970). It is evident that her interest in plant pathology largely determined the direction of Kerling's life, but she always retained a keen interest in biology in general.

Her first publication (1) was the earlier mentioned thesis on the anatomical structure of leaf spots. The problem underlying these investigations was how far plant reactions following infection or injury were essentially different from those in the healthy, uninjured plant. In the introduction to her thesis Kerling speaks of "schijnbaar afwijkende reacties" (apparently deviating reactions) thus virtually providing the answer. This is further elaborated in the conclusion on p. 49, which reads as follows: "Het blijkt dus, dat het niet een specifieke, door de schimmel of de bacteriën afgescheiden, of op andere manier ingebrachte stof is, die een bijzondere reactie tot stand doet komen, waarbij iets nieuws ontstaat, maar dat onverschillig waardoor, latente vermogens van het weefsel tot uiting gebracht kunnen worden."[1]

As appears from this first publication Kerling was already impressed by the dynamics of life phenomena, which, when dealing with the development of the leaf spot, she expressed as follows:

"...moet toch steeds voor ogen gehouden worden, dat vanaf het ogenblik van aantasting tot dan, wanneer het gehele blad zal sterven, er onophoudelijk veranderingen in de toestand komen. Processen, zoals veranderingen van celwand en -inhoud, celvergroting, celdeling, enz. spelen zich niet alleen af achter, maar ook naast elkaar op verschillende plaatsen van de vlek."[2]

[1] "Thus it is apparent that it is neither a specific substance, excreted by the fungus or bacteria, nor an alien substance, that brings about a special reaction giving rise to something new, but that – irrespective of the cause – latent potentialities of the tissue are activated."

[2] "...it should always be kept in mind that from the moment of infection until the whole leaf dies, changes are incessantly taking place. Processes such as changes in the composition of cell wall and cell contents, cell growth and division take place not only following each other but also concurrently at different places in the lesion."

This interest in the dynamics of life phenomena is found in several publications, especially in her inaugural lectures which are both entitled: "De phytopathologie, wetenschap van het dynamisch evenwicht" (19, 20).

Kerling was also interested in virus diseases, as was already apparent in the first period of her scientific activities. One year after the publication of her thesis she published the result of a microscopical investigation on pseudo-netnecrosis and "kringerigheid" (spraing) of the potato (2). At that time the cause of spraing was unknown, although it was suspected that the trouble was brought about by a virus. We know now that the disease is due to a soil-borne virus spread by nematodes, occurring in special soils. Macroscopic symptoms of the two diseases were quite different, but microscopically it was impossible to distinguish between them. The result of this investigation agreed entirely with those in her thesis, in which she stated that the response of the plant was the same, however, different the cause of the necrosis.

In the early stages of Kerling's career in the tropics her time and attention were almost entirely taken up by teaching. A few general publications, intended for secondary education, appeared on the genetics, morphology and physiology of plants and even on human nutrition (3, 4, 6, 7). However, after a few years, Kerling's interest was again attracted by scientific problems and her spare time spent on research. Working closely together with her good friend Thung on a peculiar disease of tobacco, known as "kroepoek" disease (tobacco leaf curl), Kerling made anatomical investigations on two types of this disease, which are morphologically as well as anatomically quite distinct (5). She concluded that the "kroepoek" diseases were probably caused by two different viruses. Her studies demonstrated the necessity of carrying out anatomical investigations in order to become fully acquianted with the backgrounds of the interaction between certain pathogens and their hosts. In reading this publication one is impressed not only by the excellent descriptions, but also by the many careful drawings made.

Still more than to pathological problems, at that time Kerling's attention was directed to periodicity phenomena, of which there are many examples in the tropics. As a first object of study *Zephyranthes rosea* was chosen; it flowers abundantly in various localities of the same region at the same time. First, an analysis was made of the circumstances leading to flowering. In a number of simple experiments it was shown that temperatures from 18° to 23 °C for short periods and small quantities of water suffice to promote the further development of buds after they have attained a certain size. Six days later massive flowering occurs (8, 9).

Later, attention was paid to the physiological background of the phenomenon. It appeared that the developing flower bud stops growth when it has attained a length of 28 mm, at which stage the egg cell in the embryosac and the pollen grains in the pollen mother cells have just been formed. It was suggested that the embryosac and the pollen grains contain a precursor of a growth substance, which is converted at a low temperature to an active growth regulator inducing extension of the flowerstalk.

During her leave of absence in 1935–1936 Kerling was able to complete these investigations with a study on the morphology and development of *Zephyranthes* (10) at the "Laboratorium voor Plantenphysiologisch Onderzoek" at Wageningen. Here, under the directorship of Blaauw, fundamental research on periodicity of bulbous plants was carried out. It is striking to see how much Kerling was able to integrate the morphogenesis of the plant with the physiological processes inducing flowering –

processes, which occur only when certain environmental conditions are fulfilled.

In a later phase of her stay in the tropics the periodicity of the rice plant was chosen as a research topic. It was carried out at the "Algemeen Proefstation voor de Landbouw" at Buitenzorg (Bogor) (13, 16). These investigations concerned the development of two rice varieties grown under controlled conditions and the effect of day length on the developmental processes. They, also, demonstrated Kerling's interest in morphogenesis and her great ability for accurate observation.

During her time of convalescence in Australia, Kerling undertook a mycological study on *Pythium* species isolated from non-emerging pea seeds and some other plants (12). In this paper she described the growth habit of the cultures she isolated and the structure of sporangia, oogonia and antheridia. The delimitation of the species appeared to be difficult and led to the remark: "It is clear that in view of the methods of reproduction concerned and the obvious chances of hybridization, intermediate forms can be expected". From this time also dates a general article on the open spaces of Australia (11).

On her return to The Netherlands at the age of 46, she devoted herself wholly to plant pathology, first at Wageningen and later at Baarn. In 1946, she was appointed as a research worker at the former "Laboratorium voor Mycologie en Aardappelonderzoek" of the Agricultiral University, Wageningen. This period was marked by a great activity in teaching as well as in research. She very quickly became throroughly acquainted with the practical course ("kweekpracticum") given for advanced students. At that time specialization in plant pathology was not yet possible, so students of Agriculture, Tropical Agriculture, Horticulture and Forestry with an interest in plant pathology followed the practical course. Many of the students of the period 1946–1952 remember Kerling's stimulating personality. One of these years Kerling visited several teaching and research institutes in England. In a publication on education in plant pathology (14), written jointly with Quanjer, she described the advantages and disadvantages of the British system. She was struck by the insufficient communication between the British experiment stations and farmers and growers, and also by the fact that at the Universities plant pathology was regarded only a branch of biology or botany.

Although the practical courses were time consuming, Kerling nevertheless found time for research. After an anatomical study on the attack of peas by *Mycosphaerella pinodes* (15) she focused her attention on the influence of environmental factors on the host–parasite relationship. Her two most important publications of this period dealt with the effect of nightfrost and dust storms on the occurrence of foot rot of peas (17, 21). Freezing in itself causes little damage to peas and pathogens such as *Botrytis cinerea*, *Fusarium avenaceum* and *Sclerotium sclerotiorum* are not normally harmful either. However, the combination of both factors may cause a very severe effect. A sand-blast used to imitate a dust storm, may have the same effect as freezing. Anatomical investigations showed that freezing as well as sand-blasts could cause tissue damage which could open the way to attack by parasites not normally harmful. Kerling stressed that one had here to do with a complex effect in which plant, micro-organism and changing environmental conditions all played a part. In the same period the supposed transmission of *Fusarium oxysporum* f. *pisi* through pea seed was studied (18). And it was proved beyond doubt that this pathogen is transmitted in small percentage through internal seed infection.

In her fourth period, when she became director of the Baarn laboratory and professor at the Universities of Utrecht and Amsterdam, Kerling developed the whole of her abilities. The heavy duties of these three posts, which she still holds at present, do not seem to bother her. She lectures at both Universities, and leads education and research at Baarn. Moreover she is a member of the board of several institutes. Research at Baarn continues to expand and several new subjects are being tackled. Through her initiative a new air-conditioned greenhouse has been built and several other facilities provided. In both her inaugural speeches: "De fytopathologie, wetenschap van het dynamisch evenwicht" (19, 20), some of the problems which have her deepest interest, are discussed. In the one read at the University of Utrecht, Sorauer's hypothesis stating that not only the host plant but also the parasite has a dynamic character, is discussed at length. When the metabolism of the host is changed, for instance artificially, the nutrients becoming available to the parasite may change in such a way that it can no longer damage the host. Disease is a chain of processes, determined by the balance between host and parasite. The equilibrium is dynamic, and depends, among other factors, on changes in the environment. The results of modern work on internal therapy are cited as an example of the possibility of influencing in a new way the dynamics of this balance. In her second inaugural speech Kerling draws attention to the practical implications of plant diseases for human society, and stresses that continuous efforts have to be made to maintain the level of crop production. On the one hand plant resistance to diseases has to be increased, while on the other hand the development of parasites has to be retarded. At the end the application of chemicals in the control of diseases is discussed at some length and the dangers for human health in the use of some of the compounds emphasized. However, in her opinion, to feed the increasing number of people in the world, chemical control is one of the ways that will have to be used to keep the balance favourable to the plant.

Needless to say, many different subjects have been studied under Professor Kerling's direction, the results of which have often been published, either as joint articles or as doctoral theses.

For many decades the study of fungus diseases of trees has been an important topic in the research programme of the Baarn Laboratory. Kerling continued this tradition, although in later years part of the work on Dutch elm disease and bacterial canker of poplar was transferred to the "Bosbouw Proefstation De Dorschkamp" at Wageningen. In one of her earlier publications (22) Kerling described the results of her careful microscopical studies on the reactions of elm wood to attack of *Ceratocystis (Ophiostoma) ulmi*, the cause of Dutch elm disease. After injection of spore suspensions the xylem shows a discoloration somewhat behind the uppermost places where the fungus can be isolated. Colouress tyloses develop from living cells bordering non-discoloured parts of the vessels. The toxin produced by the germinating spores is indicated as the causal agent of these abnormalities. In a joint publication with Salemink et al. (49) this toxin is proved to be a glycoprotein.

Kerling followed with keen interest the breeding and selection work on resistance to Dutch elm disease, initiated by Johanna Went and later carried on by Heybroek. This work resulted in the propagation of some very promising hybrids. In her laboratory Tchernoff developed a method of propagating elms vegetatively from wound callus, which permits the production of uniform plant material for laboratory experiments.

Oak diseases were also studied (31). Many young oaks die after transplanting. Ex-

periments showed that a decreased moisture content of the branches enable *Phomopsis* cf *quercina* (imperfect stage of *Diaporthe eres*) to establish itself in the weakened or dying tissues of the bark. Thus *Phomopsis* appeared to be a weak parasite that attacks oak trees only when grown under unsuitable soil conditions.

A careful study of oak mildew (*Microsphaera alphitoides*) (41) was carried out in order to establish its mode of hibernation. Results demonstrated that infected shoots develop mainly from the highest buds of the spring shoots. It is suggested that the morphology of these buds together with the high infection level at the time they are formed predispose them as overwintering sites and thus towards seasonal transmission of the mildew.

Together with others Kerling published some papers on soil- borne pathogens such as *Verticillium albo-atrum* (48) for which several weeds, e.g. *Senecio vulgaris*, appear to be virtually symptomless hosts in fields where crop plants were previously infected by this fungus.

Another publication (44) dealt with a foot rot of *Cucurbita ficifolia* (a rootstock used for cucumber), caused by *Nectria haematococca* var. *cucurbitae* (*Fusarium solani* f. *cucurbitae*). The pathogen was found to be seed-borne and infection can be prevented by using only seeds from undamaged fruits and by regularly steaming the soil in which the seedlings are grown. The disease originates from holdings specializing in the grafting and from which growers order the cucumber plants they need for crop production. *Cucurbita ficifolia* is used as a rootstock because it is resistant to a number of *Fusarium* species. It was successfully grown in The Netherlands for over 15 years before the first infection with *F. solani* f. *cucurbitae* occurred.

Kerling and de Lange (47) published the results of a study on the cause of bacterial canker of poplar, a disease known for a long time in The Netherlands. In the literature two different bacteria had been claimed as the causal organism. De Lange and Kerling proved that *Aplanobacterium populi* induced the typical symptoms when inoculated into freshly formed leaf scars.

Three publications on virus diseases resulted from investigations carried out by students and by Hendrina Brants, who as Lecturer in Virology at Baarn later took over the task of research and teaching on viruses and virus diseases. The first paper (30) dealt with a virus in *Atropa belladonna* which appeared to be soil-borne and transmissible by nematodes. The rod-shaped virus particles were similar to those of tobacco rattle virus, of which it was regarded as a strain. Studies on the multiplication and transport of potato virus X in *Gomphrena globosa* (35) revealed that after a latent period of 30 h the virus content of the leaves increased slowly until the 4th day, then rapidly, reaching a maximum about the 9th or 10th day, after which no further increase could be demonstrated. In the tissues outside the lesions no virus seemed to be present. The activity of some component in the cells of the *Gomphrena* leaf was suggested as inhibiting virus multiplication and translocation. In a third publication (46) a virus-free region was described as occurring behind the tips of excised tomato roots infected with tobacco mosaic virus. Several chemicals were tested for their effect on virus distribution. It appeared that after their application the length of the virus-free zone varied greatly.

In addition to the subjects mentioned, Kerling was greatly interested in the phyllosphere and nowadays the rhizosphere is also in the research programme. The first investigations in this field (26) dealt with the fungus flora on the leaf surface of beet

during the course of the growing season. *Cladosporium herbarum* and *Alternaria tenuis* appear to be the most common inhabitants. The numbers found are greatly dependent on temperature, rainfall, air humidity and leaf age. Some saprophytes cannot be washed off, apparently because they are attached to the leaf surface or have penetrated superficially. *Phoma betae* can be found in the surface flora without having penetrated. In a later publication (38), leaves of rye and strawberries were investigated. With strawberries the age of the leaf plays a predominant role, the older leaves carrying far greater numbers of micro-organisms than the younger ones. In a paper read at the International Symposium of Phytopharmacy at Gent in 1959 (29) the whole problem of the influence of excretion and uptake through the leaf epidermis on the leaf function itself and on the leaf surface flora, including pathogens is discussed. It is suggested that ectodesmata play a part in the entrance of viruses into the epidermal cells.

Her students will always remember Professor Kerling's carefully prepared and brilliant lectures and her stimulating remarks when they studied a special subject for their "doctoraal" or Ph. D. degrees. The wide diversity of subjects in which she was and still is interested gave her students a good general outline of the many aspects of plant pathology, both fundamental and applied.

Professor Kerling possesses an outstanding self-discipline and a great devotion to her work and these characteristics have made her an example to many generations of students. Her cheerful personality has won her many friends. It is gratifying that the 75th anniversary of the "Phytopathologisch Laboratorium Willie Commelin Scholten" at Baarn, which she has directed for eighteen years, could be celebrated some months before her retirement.

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