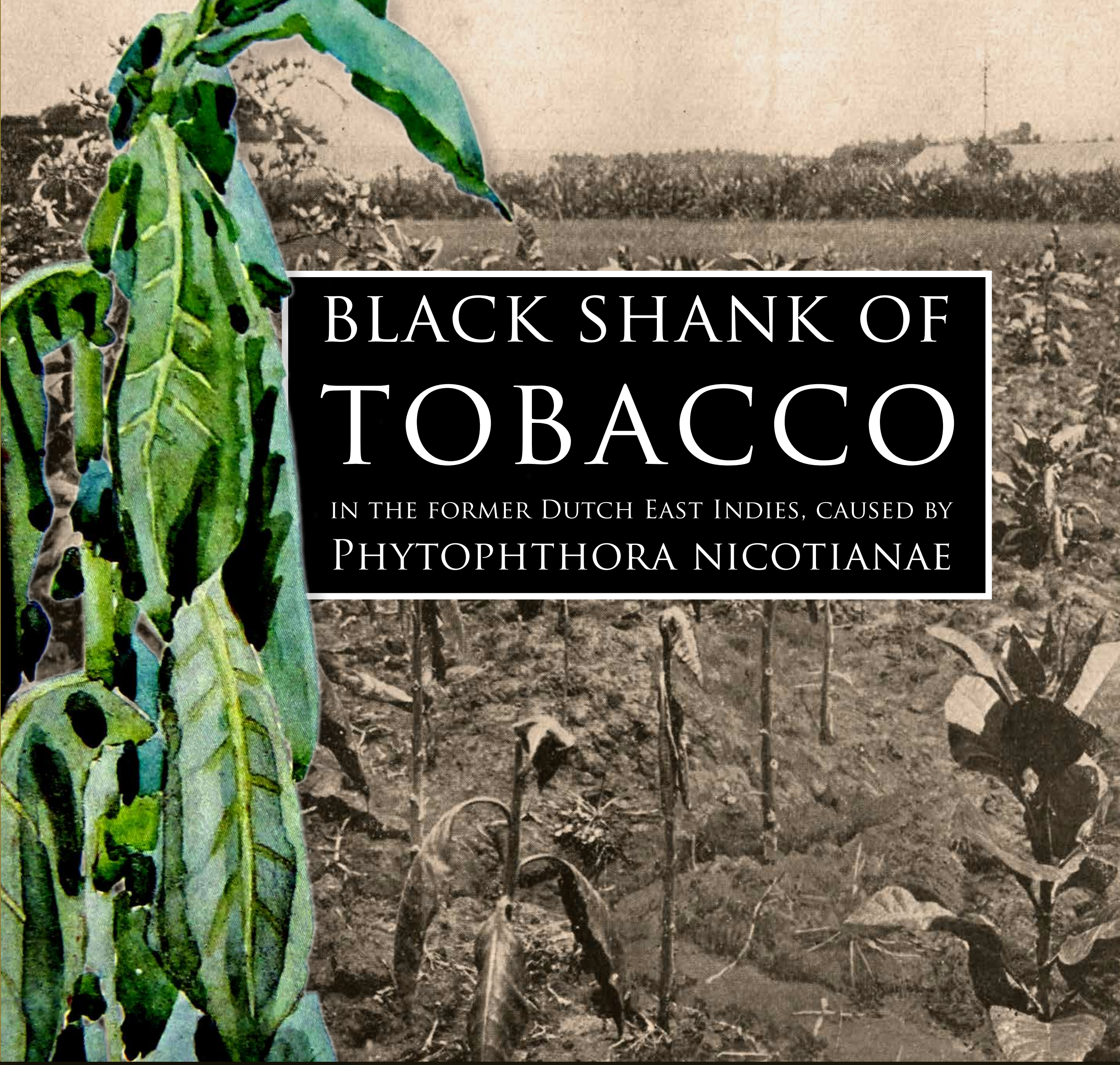

BLACK SHANK OF TOBACCO

IN THE FORMER DUTCH EAST INDIES, CAUSED BY

PHYTOPHTHORA NICOTIANAE

ORIGINAL PAPERS BY

JACOB VAN BREDA DE HAAN, 1896
AND THUNG TJENG HIANG 1931 & 1938

INTRODUCTION, TRANSLATION & DISCUSSION BY

JAN C. ZADOKS

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in the former Dutch East Indies, caused by

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Contents

Preface

'Black shank' is an important disease of tobacco, known of old in Indonesia, formerly the Dutch East Indies, and first described by Jacob van Breda de Haan, 1896.[1]

His duty was to find a remedy for a threatening disease, then and there called 'bibit disease'. He found a remedy, indeed, a control that was partly ecological and partly chemical. In addition, he identified the causal agent, as a by-product nearly. This was in a district called Deli, on the Indonesian island of Sumatra. Van Breda de Haan also made some epidemiological comments. His taxonomic identification was a 'first'.

Black shank was a problem too in another tobacco growing area of Indonesia, called the Principalities (in Dutch the '*Vorstenlanden*'), on the island of Java. The environmental conditions and agricultural practices in the Principalities differed considerably from those in Deli. On Java, research on the disease, primarily on its avoidance, had been going on from 1913 at least.[2]

It was summarized and amplified by Thung in a comprehensive report, 1938. His remedy combined ecological, chemical and genetic approaches. Thung's publication has the word 'epidemiology' in its title, another 'first', at least in the Dutch phytopathological literature.[3]

In 1931, Thung had presented a lecture, with the word 'epidemiology' in the title, that can be seen as a prelude to the extensive 1938 study. His targeted use of epidemiology and his numerical approach of 'comparative epidemiology', in which 'black shank' was contrasted to two virus diseases, was very original.

The three papers, 1896, 1931 and 1938, were written in Dutch and appeared in Dutch East Indian report series. Hence, their contents are not well known internationally. These papers, however, merit to be more widely known because of the originality and the effectiveness of the research, performed under conditions that were very primitive compared to those of today.

In Chapter 1 some comments will be made on tobacco growing in the former Dutch East Indies. Chapter 2 introduces the two authors, van Breda de Haan and Thung. Chapter 3 contains the paper by van Breda de Haan, 1896, Chapter 4 that by Thung, 1931, and Chapter 5 Thung's 1938 paper. Chapter 6 reviews the life and work of van Breda de Haan.[4] Chapter 7 offers some afterthoughts.

Hopefully, these translations and discussions will contribute to the knowledge of the history of phytopathology.

Jan C. Zadoks

Chapter 1

Tobacco growing in the former Dutch East Indies

1.1. Tobacco in Indonesia

Present Indonesia, in the time of van Breda de Haan and Thung the 'Dutch East Indies', consists of a belt of islands, the Emerald Belt, on and just south of the equator. Before World War II, the economy was largely based on the export of oil, minerals, and agricultural products, among which tobacco. The two major tobacco areas were located on the islands Java and Sumatra.

The Indonesians used to grow tobacco for their own use and for local trading. The origin of this tobacco must be sought in the Philippines, and beyond, in Latin America. Commercial tobacco growing, primarily for export to Europe, began in the 19th century. On Java the development of tobacco cultivation was gradual, on Sumatra it was explosive.

Figure 1.1. Early wilting of tobacco attributed to the black shank pathogen. North Carolina (USA), 13 August 1979.

1.2. Java, the Principalities

1.2.1. The situation on Java

The '*Vorstenlanden*', Dutch for Principalities, covered an area on mid-Java that was still ruled, at least with regard to religious affairs and local law or '*adat*', by two princely families. The rulers were the Sultan of Jogjakarta and the Susuhunan

Figure 1.2. An adult tobacco plant suddenly affected by lanas [= wilt]. From Jensen (1920), del. J.Th. Skovgaard.

of Surakarta.[1] The Principalities are the remnants of a large 15th and 16th century Muslim realm. The language of the area was Javanese, not Malay which was the *lingua franca* of the Dutch East Indies.[2]

The Javanese tobacco area was situated in the Principalities, regency Klaten, roughly half-way between the cities Yogyakarta and Surakarta. The agriculture of Klaten was tropical lowland, rainfed agriculture, with rice as the main farmers' crop and tobacco as an important estate crop. The export tobacco was called '*Vorstenlanden-tabak*'.

Klaten has a tropical monsoon climate with a short dry season. Total rainfall is about 1840 mm per year. The dry months are July, August and September, with a rainfall of about 30 mm per month and with about 9 sunshine hours per day.

Vleklanans.

Figure 1.3. Lanas lesions on tobacco leaves. From Jensen (1920), del. I. Christiani.

Monthly mean maximum temperatures vary from 30 to 33 ºC, and minimum temperatures from 22 to 23 ºC. November through April are the wettest months with 22 to 26 rain days per month. The darkest month is January with an average of 4 sunshine hours per day (Annex 1).

The *Vorstenlanden* tobacco was grown on estates run by the Dutch, sometimes side by side with native tobacco grown in and around the '*dessas*', the villages. There was a degree of understanding between the estate-managers and the *dessa*-people. The *dessas* provided labour and manure. The estates allowed the villagers to grow rice on their land during the 'fallow' years. River floods called '*bandjirs*' were used to flood and silt up the land, to the benefit of both rice farmers and tobacco growers.

The *Vorstenlanden* tobacco estates were annihilated during World War II and the subsequent political troubles that – in the end – gave rise to the Republic of Indonesia.[3] In modern times the Klaten regency and adjacent areas produce tobacco again, mainly for the Indonesian market.

1.2.2. The tobacco culture in the Principalities

In the modern view the pre-war tobacco production in the *Vorstenlanden* was small business. The total area under tobacco was about 8000 *bouws* or just over 6300 ha (p 131).[4] The Experiment Station had 18 member estates in 1936. In that year, the areas under tobacco of 15 members varied from 346 to 686 *bouws* with a median of 522 *bouws*, that is 274 to 542 ha with a median of 413 ha (Coolhaas, 1938). One of the estates had a planted area of about 400 ha. With a biannual rotation and some 200 ha service area (buildings, sheds, roads) such an estate would measure about one thousand ha. It seems that the tobacco fields were the property of the estates.

Tobacco was grown in a two-year rotation. Thung used the Dutch term '*wisseling*', here translated as 'alternation', for rotation. The area under the standing crop was seen as the 'present' alternation and the area for the next year was the 'other' alternation. His text sometimes mentions even years which alternate with odd years. In the 'even' years the tobacco fields apparently drained off to the 'big river'.[5] During the off-season, the 'odd' year, the tobacco fields were used for rotation crops such as rice, crotalaria (green manure), and others, and sometimes they were fallowed. Apparently, villagers were allowed to use the off-season fields to lay out their rice nursery beds and to grow one to three successive crops of rice, the so-called 'consent-rice'. It is not clear whether the villages had to pay for the consent. In fact, the estates needed the wet rice paddies for soil disinfection, though crotalaria and dry fallowing with intensive tillage had a similar effect. It seems that the rice nursery beds were scattered haphazardly over the fields. Since they were heavily manured with possibly infested material the estates might have a problem.

The growth period of tobacco from seed to adult plant was about five months. The tobacco was sown in nursery beds and transplanted after two to four weeks. Planting density was up to 25.000 plants per ha if small, thin and pale leaves were needed as cigar wrappers. The leaves were picked leaf by leaf from bottom to

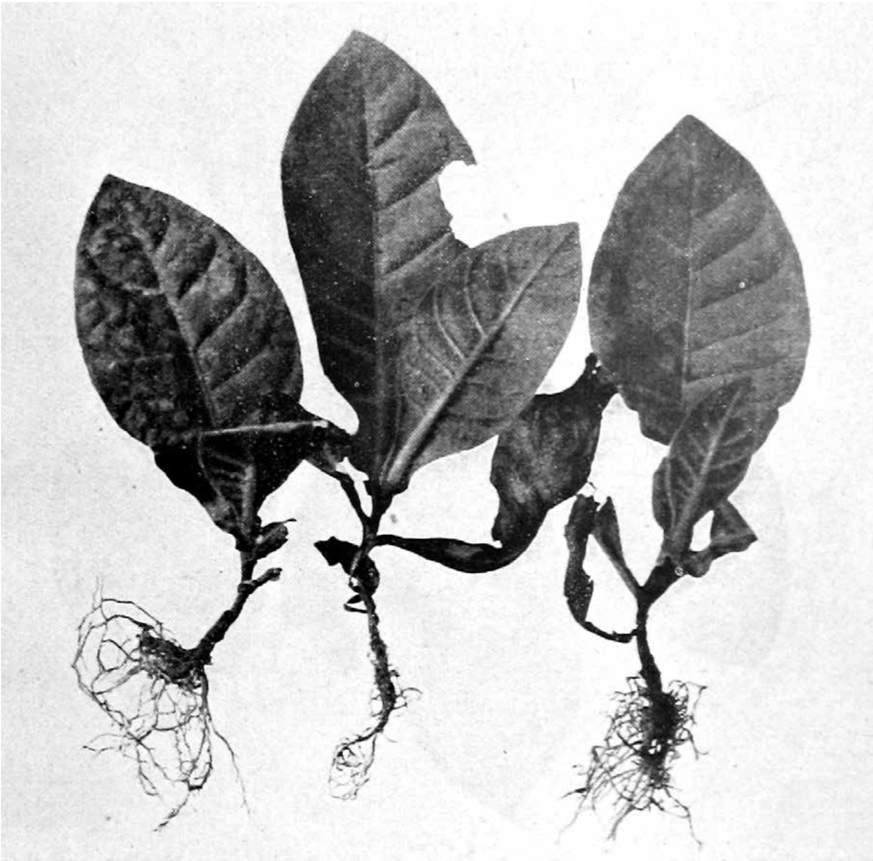

Figure 1.4. Tobacco bibit attacked by lanas. The base of the stem has blackened and dried. From Jensen (1920).

top. The lowest leaves, with fine veins, good aroma, and light brown colour were preferred. Relevant details of tobacco cultivation in the Principalities are given in Chapter 5. The tobacco calendar of the *Vorstenlanden* is outlined in Annex 1.

Artificial fertilizer was avoided as much as possible. The tobacco fields were usually fertilized with manure bought from the villagers. The paper does not describe the composition of the village manure nor its usual treatment, but it points out the risk of infestation by the black shank pathogen. I surmise that the manure consisted of animal dung, household refuse, and various plant remains, some of these infested. Possibly, human excrements were incorporated too. The manure should be piled up for self-heating, but obviously the heating frequently was inadequate. Sometimes the manure was piled up in drying barns of which the posts had then to be protected against rotting. Storage of manure, and carting it in and out, were often problematic. When carting the heated manure to the field it was 'measured out' which implies that small manure heaps were placed at regular intervals for manual spreading over the field. These small heaps should not be placed on infested soil. The problems with *dessa* manure could be avoided by the use of crotalaria green manure.

1.2.3. Crop protection problems

The tobacco estates exploited a research station called '*Proefstation voor Vorstenlandsche Tabak*', Experiment Station for Principalities Tobacco. The academic staff consisted of a director-selectionist, an agricultural chemist, and a plant pathologist. They had a staff of some 36 persons (nearly all locals), a

Figure 1.5. The black stem base of an old lanas plant. From Jensen (1920) Plate 4, del. J.Th. Skovgaard.

laboratory, a library, and tobacco sheds at their disposal. Tobacco processing and tobacco breeding, including resistance breeding, were part of the station's program. Apparently, the experiment station had access to experimental plots and to data collected by the estates. The station published reports in a series '*Mededeelingen Proefstation Vorstenlandsche Tabak*' (Communications Experiment Station Principalities Tobacco).

Figure 1.6. The 'disking symptom' or 'chambered' marrow in the stem base of a tobacco plant associated with the black shank disease. North Carolina (USA), 13 August 1979. Jensen (1920) showed a similar but hardly reproducible photograph.

One of the crop protection problems Thung had to address was '*lanas*', the local word for black shank. The fairly *lanas*-resistant selection 'Timor-Vorstenlanden' was mentioned explicitly in the 1938 paper to be planted in danger spots. TMV-resistance was another item in the breeding program. Chemical disease control was feasible in the nursery beds, with only incidental topical treatment of plants in the field (p 31). Bordeaux mixture and arsenics were used, and soil disinfection was done with quicklime. Insect control was largely done manually, school kids being hired to pick caterpillars when needed. Crop protection details are given in text books and annual reports of the experiment station.[6]

1.3. Sumatra, Sultanate Deli

1.3.1. The situation on Sumatra

Sumatra is one of the larger islands of present Indonesia. A string of over 30 volcanoes runs all along the island from north-west to south-east. Thinly populated, the island was covered by virgin forest with game to the liking of European hunters. In the second half of the 19th century the political situation in the former

Figure 1.7. Tobacco plant dying due to black shank disease. North Carolina (USA), 13 August 1979.

Dutch East Indies outside Java was somewhat uncertain. The Muslim population of the northern tip of the island Sumatra, an area called Atjeh, considered itself independent. The governmental interest in the other parts of the island was limited, at best.[7]

The Sultanate of Deli reaches back to 1630. Deli is the area around the city of Medan, in the then regency North East Sumatra. The regency lies on the western side of the Strait of Malacca, opposite to present Malaysia (Annex 2). At the time, the area was thinly populated, with virgin forests on marshy soils, frequently flooded.

Around 1860 the Sultan of Deli sent an emissary to the capital, Batavia (present Jakarta), to contact possible investors. In 1863 a Dutchman, Jacob Nienhuys, obtained a concession from the Sultan for a large tobacco estate.[8] This was the start of the Sumatran tobacco boom.

1.3.2. The tobacco culture in Deli

The tobacco culture expanded rapidly and covered some 120,000 ha toward the end of the 19th century. The virgin forest was cut down. All kinds of soils were tested and many different soils types were found to be suitable. Chapter 3 provides information on tobacco growing in Deli. After the tobacco harvest the locals were allowed to grow a crop of rice, usually against payment in kind. Following tobacco

Figure 1.8. A field with local tobacco severely infested by lanas. Some apparently healthy plants in foreground. From Jensen (1920), Plate 1.

Figure 1.9. Burning lanas stalks in the open field. From Jensen (1920), plate 10.

or rice the forest was rejuvenated to restore soil fertility. After 8 to 10 years another crop of tobacco could be grown so that, in fact, only ~10 % of the concession area was under tobacco.

The Deli planters had a typical frontier mentality, leading at times to a kind of Wild West scenes, with little regard to the local population and the work force. A massive labour force was needed to do all the work of cutting the forest, laying out the fields, ditches, and roads, constructing and maintaining the buildings, growing the crop and picking the leaves, and preparing them for despatch to the Amsterdam tobacco auction. The number of workers peaked at about 100,000.[9] Mainly Chinese coolies were contracted from Malaysia and China. The treatment of these coolies was often horrible, cruel, even criminal, as described in a report by a public prosecutor, Mr. J.L.T. Rhemrev, sent from Batavia, to investigate complaints in 1903.

To underline the difference in treatment of labourers between the tobacco planters in Deli on Sumatra and in the Principalities on Java one quotation from the report suffices: '*This relationship comes out clearest in comparing the contact of European employees with the labourers on Java. The European on Java usually knows the language of his workforce and at times he has a kind or encouraging word for them, on the estates of the East Coast [of Sumatra] practically nobody knows the language*

Figure 1.10. A field oven to burn lanas diseased tobacco plants. From Jensen (1920), plate 8.

of the contract-labourers and European employees – as I observed repeatedly during my investigation - address them rarely otherwise than with a sneer in poor Malay, as considered necessary for the prestige.'[10]

1.3.3. Crop protection problems

Labour being cheap, the usual problems with weeds and insects were solved by hand-picking. In the beginning, diseases were absent or inconspicuous. Rather suddenly, a new disease broke out, destroying the tobacco seedlings, the *bibit*, in the nursery beds. Related symptoms appeared in the standing crop, wilting (fig. 1.1, 1.2), leaf flecks (fig. 1.3) and a black stem rot, today called 'black shank'. Natives had known the symptoms for a long time as they occurred on tobacco in their house plots, grown for home consumption or local trade. That the symptoms in nursery beds and field crops were related, were caused by one and the same pathogen, had still to be demonstrated. This demonstration was the great contribution by van Breda de Haan.

His original description of the disease symptoms, which is quite clear, agrees with modern descriptions as e.g. in the 'Compendium of Tobacco Diseases' (Shew & Lucas, 1991). He used the local name *kaki boesoek*, Malay for 'rotten foot/leg', and the planters' name 'bibit disease'. No doubt exists about the identification of the pathogen, *Phytophthora parasitica* Dastur var. *nicotianae* (van Breda de Haan) Tucker.

The symptoms were nicely illustrated in the handbook by Jensen (1920), with the blackening stem base of bibit (fig. 1.4) and adult plants (fig. 1.5), the sudden wilting (fig. 1.2), foliar lesions (fig. 1.3), the 'disking' of the adult plant's marrow (fig. 1.6), and a severely infested field (fig. 1.7, 1.8). Jensen recommended to burn affected plants either in the open field (fig. 1.9), in a furrow, or in a field oven (fig. 1.10).

Infection experiments were performed using mycelial fragments and/or zoöspores. Curiously, the term chlamydospores (p 122) appears only once. The significance of chlamydospores in the epidemiology of *P. parasitica* either was nil or – more probable – it was overlooked completely. This omission I consider to be the only serious weakness in the research of both Thung and van Breda de Haan. Root-knot nematodes, now known to aggravate the disease, were not mentioned by either author.[11]

1.4. The product

Vorstenlanden tobacco is almost synonymous with cigar tobacco, but Virginia type cigarette tobacco was produced too. Only rarely this tobacco had cigar wrapping quality. The best cigar tobacco is grown in the tropics on volcanic soils or humus-rich clay soils. It is said that wine and tobacco have in common that their colour, aroma and taste are very much determined by the interaction of soil, plant genotype, cultural methods, and processing.

By a stroke of luck the Deli tobacco proved to be of excellent cigar wrapping quality, making high prices on the Amsterdam tobacco market. For some time the return on investment was up to 100 % annually, with a peak in 1887.[12] No wonder that the planters became panick-stricken at the sight of a disease threatening their wealth, the dreadful 'bibit disease'.

Chapter 2

The authors

2.1. Jacob van Breda de Haan

2.1.1. The author

Jacob van Breda de Haan was born in Haarlem, the Netherlands, November 13th, 1866. He studied botany at Leyden University, the Netherlands. As a student he participated in a foray to the Caribbean, which may have aroused his interest in tropical botany. His Ph.D. thesis, 1891, described the anatomy of the genus

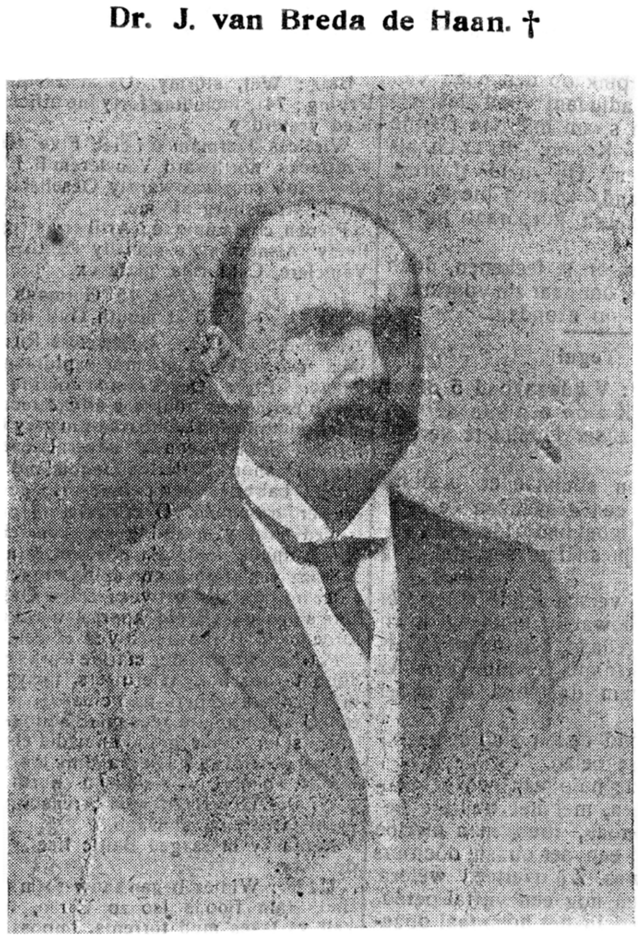

Figure 2.1. The only known portrait of Jacob van Breda de Haan, published with an obituary by the newspaper 'Bataviaasch Nieuwsblad' of 16 October 1917. Source: Royal Library at The Hague.

Melocactus, a genus encountered overseas. Shortly after his thesis defense he boarded ship for the Dutch East Indies.[1] He was stationed at the Botanical Garden in Buitenzorg, present Bogor, in the hills at some 60 km south of Batavia, present Jakarta, with its botanical and agricultural research establishment.

In 1893 the director of the Botanical Garden, Dr. M. Treub, made an arrangement with the Deli tobacco planters in which they would pay for a botanist, stationed at Buitenzorg.[2] Van Breda de Haan got the job. Several times he travelled by ship from Java to Deli for study and experimentation. Library consultation, laboratory work, and some field experiments were performed at the Botanical Garden.

Van Breda de Haan is a forgotten plant pathologist (Chapter 6). He was an excellent observer. His most original study was on the 'bibit disease' of tobacco, caused by a fungus-like organism which he called *Phytophthora Nicotianae nov. spec.* (p 66). Van Breda de Haan studied diseases of several other crops among which sugar cane, pepper and rice. His interest in general ecology is shown by his concern about the effect of deforestation on the Deli climate and by his introduction to a set of agro-meteorological tables. Around 1905 he became the director of the governmental Experiment Station for Rice and Secondary Crops at Buitenzorg, with the title 'Inspector of the Indian Agriculture'. He also headed the extension service for the native farmers. Van Breda de Haan died in 1917, in Batavia (Fig. 2.1).

2.1.2. The science

Van Breda de Haan had not been educated in plant pathology; he was a self-made phytopathologist. His experiments, sometimes without replications, were logical and to the point. A shade of doubt exists as to the identity of the pathogens tested in Buitenzorg. Van Breda de Haan himself wrote about strains that produced either conidia only or oöspores only, being morphologically identical and infecting tobacco as usual (p 63). Shew & Lucas (1991) commented: '… *but he described a mixed culture and failed to give a latin description for the organism*'.[3] The first part of that comment may be true, the second part is certainly correct but the word 'failed' is a bit harsh.

Van Breda de Haan knew the 19th century custom to name pathogens after their host plant. He considered it rather a temporary device in anticipation of a detailed study by a fungal taxonomist combining microscopy with infection experiments on an array of host plant species (p 66). That may have been the reason for omitting a pathogen description in Latin; none of his sponsors would be interested in a Latin description of the causal organism.

Van Breda de Haan's epidemiological comments are casual and scattered. We first look at passive dispersal. Dispersal of mycelium fragments by man and his implements was acknowledged as the major way of dissemination (as on p 43, 54). Hints to wind dispersal were given (p 43, p 52) without making clear what was dispersed, conidia or mycelial fragments, the latter possibly packed in wind-blown water droplets. Splash dispersal has not been indicated but dispersal by running water, presumably of mycelium fragments, was mentioned (p 58). Passive dispersal of oöspores was indicated (p 49, 64). Active dispersal by zoöspores was mentioned (p 64). Survival of the pathogen in the soil was evident, but how? As oöspores, as mycelium surviving on plant debris, or as chlamydospores? The longevity of oöspores and their survival function were indicated. Chlamydospores were not mentioned and they are not evident in fig. 3.2. Apparently van Breda de Haan did not know their existence. Note that explicit epidemiological thinking is a 20th century development, as exemplified in Thung's papers (Chapters 4, 5).[4]

The field studies in Deli were well-done. The 'nursery bed' was the experimental unit. The experimental design is impressive, eight experiments ('experimental fields' in the text) of fifty nursery beds each. These experiments were distributed over eight estates at different distances from the sea, at different altitudes, with different soil types. Two variables were chosen, chemical treatment and ecological treatment. The chemical treatment had four levels, three with and one without Bordeaux mixture. The ecological treatment had four levels too, different levels of sheltering to regulate access of light and air to the plantlets in the nursery beds.

All experiments had the same lay-out, non-random, but with a fairly regular distribution of treatments over the plots (p 71). At the time, statistics were non-existent. The author made a very careful descriptive analysis of each experiment, separating ecological and chemical effects first, then combining the two. Finally, he lumped all experiments together to derive a general conclusion. This procedure was successfully applied to the results of the chemical treatments but less so to those of the ecological treatments.

Disease assessment was made per nursery bed, using three classes: serious, sporadic, and absent. These classes were not described in detail so that the personal judgment of the local observer may have been a confounding variable. This indefiniteness clearly did not pose serious problems of interpretation.

The general conclusion of the chemical treatments was that a correct application of Bordeaux mixture rather satisfactorily controlled the disease in the nursery beds. This is no wonder because the disease is caused by a peronosporaceous pathogen. The positive effect was continued after transplanting in two ways, first by avoiding transfer of the disease from nursery to field, and second by transplanting treated plantlets that were in better shape than the untreated ones. Field experiments treating a transplanted crop have not been considered.[5]

A general conclusion about the ecological treatments could not be drawn because of the interference of the weather that varied much between locations. Per experiment some valuable conclusions could be drawn. The overall impression is that removal of the shelter over the nursery bed some days after emergence had a favourable effect on the development of the plantlets and reduced the impact of the disease, but only when the weather was not too wet. With frequent and heavy rainfall the permanently sheltered nursery beds did better than those from which the shelter was removed, even for short periods.

The organisational effort to get these experiments done and duly reported, all with exactly the same design but on eight different estates, with different personnel, soil, altitude and weather, must have been immense. The experiment comprised 400 plots (nursery beds). As far as I know no experiment of this size had ever been done in the Netherlands before ~1900. In the Dutch East Indies of the time, tobacco growers had no lack of money and labour; they must have been eager to be engaged in this experimentation because they really feared for the continuity of their business due to an incomprehensible disease. Curiously, van Breda de Haan did not mention the year, well-known to the insiders, in which the experiment was done: 1894.

Van Breda de Haan also organized an enquiry among practicians. Forty nine estate managers responded. Such an enquiry, with analysis of the responses, is another great effort. Generally, the results agreed with those of the experiments. Some estate managers reported their own experiments, as e.g. an experiment with forty plots (p 94). Another estate manager wrote that of his eight thousand nursery beds only four or five became diseased. Here again the size of the operations is impressive.

The pressure on van Breda de Haan to obtain and communicate results made itself felt. He wrote two interim reports, a 'Preliminary report on the bibit disease in the tobacco' in 1893, and a 'Report on the experiments to control the bibit disease in the tobacco' in July, 1894. In March, 1894, he lectured in Deli on the results of the field experiments.[6] The more formal publication of 1896 (Chapter 3) contained the drawings that warrant van Breda de Haan's authorship of the pathogen's name (Fig. 3.2), *Phytophthora Nicotianae nov. spec.* (p 66), forgiving the lack of Latin description.

2.1.3. The language

The objectives of the 1896 paper clearly were two-fold. First, it is a report intended to convince tobacco planters, traders and financiers of changing their cropping methods and applying chemical and ecological control of a disease hitherto poorly understood. Second, it is an important scientific report, as acknowledged in the international literature by attaching the author's name to the name of the pathogen.

The first objective had its effect on the language used. Great interests were at stake. Urgency pervades the report, which is sloppy, long-winded, and repetitive. Van Breda de Haan admitted that he used parts of earlier reports (1893, 1894) practically without change (p 35). He ended most chapters with a rather concise conclusion, most explicit and even italicised (p 88). His last chapter contained the final conclusion, printed in italics, succinct and convincing (p 96).

Van Breda de Haan wrote an easy going Dutch, pleasant to read because it approached the spoken language his readers must have been used to. The language contains some typical twists derived from colloquial Dutch such as the far too frequent use of interjections such as '*echter*' = 'however, but' and '*dus*' = 'thus, hence'. Many of these interjections have been omitted in translating without harm to the legibility of the text. Some words were used rather loosely, as e.g. in 'nursery beds were diseased', where today nursery beds are no living entities and cannot be diseased, though the plants on the beds can. Most paragraphs are quite brief, often just one sentence long, leading to a kind of staccato in writing.

Van Breda de Haan's Ph.D. thesis and his other papers were written in a crisp style, concise and precise, in contrast to the present text. Apparently his change of style was intentional. My impression is that the manuscript was written in

Dutch	English	scientific term
blaasje	thinwalled vessel	vesicle
conidiëndrager	conidia bearer	conidiophore
eispore	egg-spore	oöspore
kiemdraad	germination thread	germination hypha
scheidingswand	separation wall / septum	septum
slijmprop	mucus plug	papilla
trilhaar	vibrating hair	flagellum
spermatozo	spermatozoön	zoöspore
verschijnselen	phenomena	symptoms
zwermspore	swarm-spore	zoöspore

Table 2.1. Terminology as used by van Breda de Haan, 1896.

haste and printed in a hurry, without the 'second look' usual with scientific texts. The brief delay between experimentation (1893, 1894) and completion of the manuscript (November, 1895) supports this view. The final report appeared in 1896. The impressive rapidity of reporting will have done justice to the obvious anxiety of the planters and their financiers.

The author preferred to use Dutch words instead of current scientific terminology, wherever possible (Table 2.1). Just one example: the word 'hypha' was avoided and instead the term 'mycelium thread' (Dutch: *mycelium draad*) was used. In this way, I suppose, the author wanted to emphasise his message to a readership inexperienced in scientific matters. At the end of section 2.4 pathogenesis is explained to the ordinary planter in a nearly childish way (p 55).

2.2. Thung Tjeng Hiang

2.2.1. The author

Thung, a native of present Indonesia, then the Dutch East Indies, was born in 1897 at Buitenzorg (present Bogor). He was the first son of Chinese parents whose ancestors had, several generations before, emigrated from South China to Java. Their language had become a local mixture of Malay and Sundanese.[7] Their children were the first generation to be admitted to Dutch schools. Teenagers of that generation tried to learn their forgotten ancestral language, inspired as they were by the revolutionary modernization of China under Sun Yat Sen. Thung Tjeng Hiang thus became acquainted with two languages unknown to his parents: Dutch from the age of four years and Chinese from his high school years onward.

Thanks to his Dutch high school training in Batavia he could in 1916 enter the College of Agriculture, presently the Agricultural University, at Wageningen, the Netherlands, where he obtained the degree of '*ingenieur*', equivalent to the present master's degree.[8] Meanwhile he had also spent some two years studying Chinese and philosophy at Leiden University, the Netherlands, and at Berlin University, Germany. Following visits to China and Indonesia in 1920 and his marriage in 1923 he returned to Wageningen to specialize in phytopathology.

His Ph.D. thesis, entitled 'Physiological investigations to the virus of leaf curl disease of the potato plant, Solanum tuberosum L.', was completed in 1928 under the supervision of the then famous plant virologist Hendrik M. Quanjer.[9] After a year spent at the 'Institut Pasteur' in Paris (France) Thung returned, with his family, to Indonesia.

From 1929 to 1939 Thung worked at the Experiment Station for Principalities Tobacco at Klaten, on Java. One of the diseases studied was *lanas* or 'black shank'. In 1939 Thung was appointed Head of the Mycological Subdepartment of the Institute for Plant Diseases at Buitenzorg, where he continued to work during World War II. There, he was able to help many people in distress during the Japanese occupation of The Dutch East Indies.

Figure 2.2. Professor Thung Tjeng Hiang. Source: Professor J. Vlak, Department of Virology, Wageningen University.

After the war and before December 1949, when the Republic of Indonesia was officially recognized, Thung remained active on behalf of the Institute for Plant Diseases, which the Dutch – locally still in power – planned to upgrade to university level. He was asked to develop a curriculum in phytopathology but he soon became aware of the vanity of the projects in that period. In September 1949 Thung left Indonesia for the Netherlands, where he became head of the virology department at the Institute of Phytopathological Research in Wageningen, and part-time professor of virology at the Wageningen College of Agriculture. He also prepared his book 'Principles of plant virology', that was published in Dutch, 1949.

Thung travelled widely, i.a. to the USA, USSR, India and Africa. In 1957 he revisited Indonesia as a guest professor at the Agricultural College of Bogor. In 1958 he received a stipend from the Rockefeller Foundation to visit the USA, where he participated in the 50th anniversary of the American Phytopathological Society. In 1960 he lectured in China, at the invitation of the Academia Sinica. Thung (co)authored well over 70 scientific papers and reports, mostly in Dutch.

In his *in memoriam* J.P.H. van der Want wrote about the potato virus conferences Thung had organized.[10] '*Knowing the great political contrasts in the world and being much concerned about the dangers of war in this nuclear age, Thung tried to bring together his colleagues in the study of plant viruses in order to promote a better human understanding. It is in this context that we have to view his initiative in organizing the conferences on potato virus diseases. All those who have taken part in one or more of the four conferences will agree that they were more than mere meetings on technical problems. In fact they were manifestations of friendship and brotherhood. We shall always remember the stimulating talks Thung gave in fare-well parties at the closing of the conferences*.'

Professor Thung was a warm person, of great kindness, always ready to help people in distress, deeply concerned about the ominous course of the world at large but also trustful. He lived for his family, his science, and his desire to bring people together from different countries and different outlooks.[11] In his person he bridged East and West (Kerling, 1961). He died in 1960, shortly before retirement (Fig. 2.2).[12]

2.2.2. The science

At a small but economically important experiment station Thung worked in relative isolation during the 1930s. Nonetheless, his views and results did not appear out of the blue. He could rely upon the results of his predecessors, good researchers duly quoted. Technical assistance was not a problem as many Javanese technicians and field workers were well trained and reliable. Thung must have felt the interest but also the pressure of the plantation owners and managers: solve the *lanas* problem as soon as possible! The isolation was partly compensated by the scientific literature available at the experiment station.

During the Interbellum, 1919 to 1940, phytopathology in the Netherlands, where Thung received his scientific education, reached great heights. Professor Johanna Westerdijk at the Phytopathological Laboratory 'Willie Commelin Scholten' in Baarn was a leading figure in the study of fungal diseases and professor H.M. Quanjer in Wageningen was an internationally acknowledged leader in virology.[13]

At the time, plant disease epidemiology was not considered a subject by itself, at least not in the Netherlands. The Dutch journal on plant disease, the '*Tijdschrift over plantenziekten*', had never shown the word 'epidemiology' in the title of a paper.[14] In this respect Thung, who used 'epidemiology' as the lead-word in the title of his 1938 paper, was definitely original.[15] He must have been inspired by the colonial Dutch phytopathology with its excellent track-record of applied research. Thung's 1938 report (Chapter 5) fits in with this tradition as it led to simple and practicable recommendations.

Ecological aspects weighed heavily in Thung's view. The spread (dispersal) of the pathogen should be avoided by the appropriate management of irrigation water and manure. Persistence of the pathogen in the soil should be kept in check by crop rotation primarily, flooding included. Nursery beds could be treated with a fungicide and topical application of chemicals in the field was considered.

A well-hidden but sparkling gem in epidemiological literature is the lecture presented by Thung in Klaten, 1931, apparently for the personnel and guests of the experiment station.[16] The printed version defines three modes of studying plant disease, etiology, transmission, and epidemiology. His idea was to identify an epidemiology for each disease separately that really characterized the disease. To build his argument Thung compared three diseases which makes the paper an early example of 'comparative epidemiology' (Palti & Kranz, 1980). Since the tobacco planters in the *Vorstenlanden* were haunted by the urge to count their plants, healthy and diseased, Thung could show graphs of near-exponential increase of tobacco mosaic, non-exponential increase of '*kroepoek*' disease, and occasional explosions of *Phytopththora nicotianae*.[17]

Before 1960, epidemiological concepts had hardly been developed and epidemiological language was poor, at best. In my eyes, modern plant disease epidemiology has three characteristics.[18] The first is its intensive use of mathematics, the second is its comprehensiveness, extending over multiple levels of integration, from the molecular to the landscape level. The third is its effort to reduce or even replace chemical treatment by more subtle methods among which resistance, ecological measures, and hygiene.

At the time, mathematics were not applied in phytopathology. Evidently, the author had no notion of statistics and of mathematical analysis of disease progress curves. In the 1920s these subjects were not yet part of the phytopathology curriculum (Characteristic 1). Nonetheless, Thung looked at disease progress curves as distinctive characteristics of diseases (Chapter 4). He also advocated disease mapping (p 104, 154), another original approach, but he did not publish his maps.

The sensitive, semi-quantitative bio-assay as refined by Thung is a remarkable feat. The sampling effort is impressive. During a full year soil temperatures were measured at least twice a month, on ten different sites, two times a day. Bioassays were done every month during nearly four years at numerous sites in order to test soils and waters, all in the same way. Such long-term efforts were absent, or rare at least, in the Netherlands.[19]

The prime epidemiological merit of Thung's 1938 paper is its comprehensiveness (characteristic 2). In this respect the paper is quite modern, reaching from the test tube to the estate and its surroundings. The surroundings were seen broadly, including the river with its sudden floods and the Javanese village, thus approaching 'landscape epidemiology'. Thung proposed various hygienic measures to replace or at least reduce the then current chemical treatment that was unwieldy and expensive (characteristic 3). During the Interbellum disease resistance breeding was ongoing, with the result that Thung could recommend to plant the variety Timor-Vorstenlanden on sites at risk of '*lanas*'. The resistance of this variety to '*lanas*' was good but not complete and its product quality, though not ideal, was acceptable.

As to the nursery beds Thung followed Jensen (1920), who clearly stated that any diseased plant is a lost plant, so that all control must be preventive. Nursery beds should preferably not be watered from above but by means of small ditches. Heavily infested nursery beds should not be used, but healthy plantlets from treated nursery beds can be transplanted when no more disease is found five to six days after treatment, the incubation period in the nursery bed being only two to three days. Chemical control with Bordeaux mixture was recommended for nursery beds, usually every five days. Regular and careful inspection of the nursery beds was imperative.

As to the field crop Thung followed Raciborski (1913). Diseased plants and surrounding healthy plants must be removed without shedding adherent soil. The site of the diseased plants must be disinfected. This implies to mix some handfuls of ammonium sulphate with the site's soil, and to add a somewhat larger amount of quicklime, thoroughly mixing the two chemicals with the infested soil. The treated soil should smell strongly of ammonia.

Transplants that become diseased are treated by surrounding them with some 50 grams of fresh slaked lime that must be mixed with the soil unto 10 cm deep. The next day the dead plant must be removed carefully, without shaking soil from the roots, and carried away in a closed tin. Dead plants are to be counted and burned, preferably in portable field ovens (fig. 1.9, 1.10). Filling the empty spaces with fresh transplants is allowed when the treated soil is thoroughly mixed with surrounding soil to dilute the lime.

In my view Thung's results, with his practical recommendations, are a great achievement. He wrote pioneer studies in plant disease epidemiology. In his recommendations Thung combined three types of control, ecological, chemical, and genetic.

2.2.3. The language

Thung's 1938 paper was written in an elaborate style, with a somewhat solemn touch, the colonial style of writing lagging behind the then modern style of the mother country, the Netherlands. To the contemporary European Dutchman the colonial Dutch had an old-fashioned ring. Thung's writing style is long-winded, verbose, a bit stodgy, and the logic of the sentences is not always as we want to see it today.

Dutch was not Thung's mother tongue and this makes itself felt in subtle ways. The language of the paper varies from stately to colloquial. The sentences are rich in words that one would omit today as being superflous. The tenses are often inconsistent. Many sentences are too long with repeats such as '… that … that' which are and were considered poor writing. The very frequent use of the article 'the', maintained in the translation, is striking.[20] Sometimes a conclusion does not match with the preceding comments. Thung's English summary reflects some of these imperfections. The reports of the Tobacco Research Station were addressed to a small audience of Dutch insiders primarily. They were not peer-reviewed. This may explain certain omissions that would not have been accepted by a modern scientific journal.

Thung's terminology is a mixture of scientific words and 'plantation speak', a jargon with technical terms in Dutch and several words in the local language, either Javanese or Malay, first of all the word '*lanas*' used for the tobacco disease 'black shank'.[21] The term '*lanas*' is Javanese, here best translated as 'wilt'. Today epidemiologists would attach different meanings to the terms inoculation, infection and infestation but Thung, not yet so precise, used the term infection (Dutch: '*besmetting*') in a broad way covering all three concepts. There is an alternative – or additional – explanation of the relative awkwardness of the paper's language. At the time the vocabulary of plant disease epidemiology had not yet been well developed. In fact, the construction of a concise and clear epidemiological vocabulary began with Vanderplank's 1960 paper, elaborated in Vanderplank's 1963 book, and its development is still ongoing (Madden *et al.*, 2007). Several local terms were easily understood by the readership, such as '*riet*' (Dutch) = cane = sugar cane, '*terong*' (Malay) = eggplant, '*ambtsveld*' (Dutch) = '*loenggoeh*' (Javanese) = 'official field', and so on.

This criticism as to the language does not detract a thing from the scientific content of the paper.[22] It contains a rigorous epidemiological study at various integration levels, the test tube in the laboratory, the plant in the field, the crop on the estate, and the estate in its surroundings, the landscape. The study is field-oriented and lab-supported, low-tech, with one important innovation called the 'leaf-method', the bioassay to determine the infection level of soil, water, and manure. The method was used to assess the infectivity, in a relative measure, of over 35 different sites during 24 to 45 months. No mean feat, indeed!

2.3. The translation

Van Breda de Haan made two common 'errors' that are more or less acceptable in conversation but should be avoided in written language, even in a colloquial style. The first is the unnecessary coordination of clauses, often with an inversion of the order of subject and verb in the second clause. The second common error is a hopeless confusion of the tenses, usually without consequence for the readability and understanding of the text. Most of these errors have not been corrected in translation in order to maintain the original 'flavour' of the text. Finally, it was thought necessary in translating to change sometimes from the transitive to the intransitive use of a verb, and to change from the passive to the active form, or *vice versa*. The result is a language that any decent scientific journal should reject immediately, but remains fairly true to the original Dutch text. For Indonesian terminology see Annex 3.

Translating Thung, 1938, I tried to render the peculiar, antiquated flavour of his writing, with its curious and unexpected turns of phrase. I maintained the paucity of words on the one hand ('infection' for inoculation, infection and infestation), the abundance of words on the other hand (definite articles and adverbial particles). I tried to avoid interpretative translation as much as possible. The disadvantage of this approach is a somewhat unwieldy reading. Occasionally, a linguistic comment is given in a note. All *italics* are Thung's.

MEDEDEELINGEN

UIT

'S LANDS PLANTENTUIN.

XV

DE BIBITZIEKTE IN DE DELI-TABAK

VEROORZAAKT DOOR

PHYTOPHTHORA NICOTIANAE

DOOR

Dr. J. VAN BREDA DE HAAN

(Met plaat)

BATAVIA — 'S GRAVENHAGE
G. KOLFF & Co.
1896

Chapter 3

The bibit disease in the Deli tobacco

Jacob van Breda de Haan

3.0. Preface

In the following pages one finds an overview of all that was brought to light until this day, the research of the seedling disease in the tobacco of Deli.[1]

Now that this plague is reasonably under control, or expressed less optimistically, the control measures taken showed to be practicable and useful in practice, it seemed to be not inconvenient to combine the preliminary communications and the botanical research into one whole. Thus, new studies are not offered here, sometimes one will find here and there literally what was communicated earlier, only form and composition are new.

Be it also in this form a guide to the planter, and demonstrate that scientific research can be useful in growing a crop and that a rational control of diseases threatening our crops can be attained following a strictly scientific path.[2]

Buitenzorg, November 1895.

3.1. The tobacco cultivation in Deli

The area, where the Deli tobacco is grown, mainly comprises the residency East Coast of Sumatra; this is subdivided into several departments, of which the names and borders correspond in part with the earlier or still existing realms of the native princes. The capital Medan, in about the centre of the tobacco growing area, is situated at 3° 35' N and 98° 41' E, at a distance of 17 kilometres from the coast.

Tobacco from this whole area goes under the name of Deli tobacco; only if one wants to be more precise one speaks of Langkat-, Deli-, Serdang- and coast-tobacco, where the latter implies the produce from Padang, Bedagei, Batoe-Bahra etc.[3]

Figure 3.1 (previous page). Title page of the 1896 paper by J. van Breda de Haan. Source: Library of Amsterdam University, Special Collections.

The geographical position of Deli is certainly not foreign to the superiority of the product grown here and of great influence on climate and rainfall. A linked-up string of mountains runs along about the lengthwise axis of the island Sumatra, which splits into two branches at the height of Assahan, by which the Battak-plateau is enclosed, with Lake Toba situated in its southern part. Where this mountain chain borders Deli and neighbouring areas in the S.W. it seems to be mainly a volcanic formation of rather recent date, which forms the wall separating coastal region and upland plane. Most mountain peaks are volcanos already extinct, heavily forested.

Some are counted under the volcanos still active, such as e.g. the Sibaijac, south of Medan, with the top reaching a height of 2172 meters above the surrounding mountains. The ejecta and lava streams, which forced their way through from these volcanos, formed the southern slope of the so-called Battak plateau.

At the northern side the coastal region of Deli was formed, a relatively narrow stretch of land, which changes into undulating terrain at a short distance from the coast already. Medan is situated at 14 metres above sea level; at a distance of about 30 km from the coast the country becomes rather hilly, then rises rapidly, joining the foot of the higher mountains.

At right angle to this series of volcanos is a chain of mountains, that in the west separates Upper Langkat from the Gajo area and reaches nearly to the coast. Along the foot of these mountains run the rivers Wampoe and Besitan, of which the latter has some of its sources here, whereas the source of the Wampoe is sought in the still unknown parts of the Battak plateau.

The tobacco-growing Deli thus is a relatively narrow coastal zone, bordered by the sea in the north and otherwise enclosed by high mountain ridges. The further south one goes, the wider the coastal zone becomes.

Simultaneous with this change in the state of the land one sees a change in climate and rainfall. Most frequent are the rains in the so-called Wampoe-corner, where the mountain ranges of Atjeh and Battak meet, the more to the south the less this precipitation. Whereas in Deli one hardly notices the monsoons, and the onshore wind drives the clouds forth nearly every day which, cooled against the mountains, fall down as small rain showers, the effect of the monsoon is already felt more clearly in Assahan and further south.

That the location of Deli along the Strait of Malacca also will exert an important influence on the rainfall and the weather needs no explanation. Certainly it is not too rash to attribute part of the favourable results of the tobacco cultivation in Deli to the favourable climate.

Here follow some data, drawn from rain observations at Medan over twenty years, from which appears that during the planting months March, April, May and June 543.1 mm fell in 44 days, that is on average 12.3 mm per rain day, while nearly every fourth day brought rain.

The annual amount was, on average, 2072 mm in 164 rain days and 13.1 mm per rain day.

Thus, a persistent drought, as is experienced i.a. on Java during the East Monsoon, is here as unknown as a real West Monsoon with downpours and bandjirs.

With some words we referred already to the supposed geological origin of Deli and we gave as our opinion that the volcanic ejecta played an important role. Part of these volcanic products was later deposited again by the sea in alluvial strips; the large mass however formed the hills and the sloping terrain at the foot of the Battak-mountains. Now it seems that not only the ejecta of the various volcanos differed in physical and chemical composition, but that also one volcano, e.g. the Sibajac, has at different times thrown up either ashes or rapilli, or lava streams.[4] Here and there one finds a clear picture of this gradual coming into being, where a profile has been cut through the hills for a road or otherwise.

As is understandable, the water streaming down from the mountains carries these products and exposes them to weathering at different rates. Accordingly one finds, when leaving the clay strip extending over Deli, nearly parallel to the coastline, different soil types, changing from white soil to dark red-browns in all sorts of shades.

Below nearly free from stones, one finds these in increasing amount towards the mountains. The slopes at the foot of the mountains are strewn with large trachytic blocks of rock, which render the soil unsuitable for all cultivation.[5]

At the time when the first estates in Deli were opened, now about 25 years ago, a virgin forest covered the whole coastal area and the mountain slopes. Only along the banks of the rivers Malay and Battak people had found themselves a higher place here and there to establish their kampongs and to grow the needed rice etc. on ladangs. The first estates were opened near to these settlements, where, along the rivers, transportation encountered the fewest obstacles. The enormous expansion, which the tobacco culture took within short time, was of course accompanied by an increase [in the number] of the estates and new stretches of land were reclaimed continuously. In practice it appeared that one could not come back to the same piece of land during successive years and thus every year a new piece of forest was reclaimed. Soon, the best pieces of land were occupied and people were forced to look at areas where the desired humus layer was thinner, or where marshes had to be drained first, before one could think of growing tobacco successfully. In the beginning people were generally of the opinion that tobacco could be grown only on the flat, warm coastal strip, but gradually they were forced to move to the hilly areas, and now one finds estates nearly up to the slope of the Sibayac. In this way people talk readily about upper- and lower-estates, with a difference in altitude of sometimes over 300 m. Experience soon taught that other soil types, beyond the humus-rich black soil, were able to produce tobacco still coming up with a good price. So one finds now estates on every possible soil type and one sees sometimes one and the same estate producing tobacco of nearly equal quality on white clay, red soil and black humus-soil.

When practice had taught that nearly no place in Deli was found where tobacco could not grow, either with more or less financial result, soon the largest part of Deli was handed out in estates and herewith the virgin forest disappeared. Each year more forest giants were felled to make room for tobacco plants, which in turn were replaced by rice and alang-alang.[6] Where the jungle stretched out in former times, one now finds vast alang-alang fields and so seeing Deli one is more inclined to lament the country than to praise it generously.

These alang-alang fields were then left at rest during some 8 or 10 years, i.e. they were burnt off mostly once a year, due to carelessness. Because of this, all young forest was prevented to develop and the opinion was that the long rest alone already sufficed to yield a good product again.

In recent years the habit to leave the soil simply to itself was abandoned. Loose, porous soil is most willing to produce tobacco and thus it was attempted to till the hard crust, formed under the alang-alang, with ploughs and to make it even more productive by manuring.

At places, serious attempts were made to cover the soil with forest after the tobacco harvest, though not virgin forest. Though this reforestation is based largely on rudimentary experiments, the feasibility was already shown, and herewith Deli is possible spared the threatening disaster of change in rainfall and climate.[7]

The deforestation of this plain did not remain without consequence, especially not when people on the upper estates began to clear-fell the mountain slopes, and to leave them as alang alang fields. Instead of the so desirable soft rain showers came more and more cloudbursts, with more damage than benefit.

Now, people know, however, the means to stem the harm before it assumes still larger proportions.

With a firm hand the labour of reforestation once begun has to be continued, if Deli is to be saved for the tobacco.

Over nearly the whole coastal area estates were opened on the most diverse soil types. Some [are] situated at an altitude of over 300 m above the sea, other estates plant nearly on the beach, and under all these so different conditions a nearly equivalent product is obtained.

An estate usually consists of three, sometimes more sections, when the terrain does not allow to cultivate large continuous complexes of land simultaneously. Each year a fresh strip of land is planted, whereas following the harvest the locals grow padi on the harvested part. Mostly the sections are laid out so that the same main roads may render service during some consecutive years. Each section forms a long strip, of which a square plot of the size of ± ¾ bouw is assigned to every coolie for planting.[8] Straight across the fields run the main roads, along which the drying sheds are located, in parallel herewith run some narrow paths, while the nursery beds are located along one of these roads. For each field usually several beds, sometimes up to 30, are laid out by the coolie to whom the field is assigned. The beds are laid-out with larger or smaller intervals, according to the pace at which they are thought to be transplanted. If the site is favourably located, near a river or streamlet, sometimes also a large number of beds is placed together.

In the past it was customary to leave the care of the nursery beds nearly completely to the coolies, they then selected sometimes the best sites, but also often their laziness won and a low wet site was chosen where water for the spraying could be found nearby. Sometimes a hole was dug in one of the ditches separating the fields, in which then besides water all the dirt of the ditches collected, and this unclean water was used to water the nursery beds.

With the way of lay-out followed earlier, one thus found beds of different ages, close together, separated only by a narrow path. Besides the roofs over the beds one found usually also so-called side-tinkaps, of atap or lalang, which had to prevent the sun from penetrating at the sides.[9]

The beds were usually 18 feet long and 3 feet wide, so that the coolie could easily pick insects and worms [reaching] from the path over the whole bed. In the morning and evening the beds were amply watered, whereby usually very little attention was given to the water used by the coolie. On upper estates somewhat longer, on lower estates somewhat shorter, we can in general reckon that the bibit is ready for transplanting after well over forty days. During these forty days the beds require daily supervision to search for worms, to remove diseased plantlets and to thin.

In connection with the striving to prevent the sun from irradiating the beds, the orientation of the nursery beds is usually taken E.-W.

In order to determine approximately the right amount of seed needed per bed, a few experimental beds were sometimes laid out, and the measure for the other beds determined accordingly.

When the bibit plantlets are old enough to be transplanted the soil is wetted thoroughly and the plantlets are carefully pulled up. The first days after transplanting they are yet shaded by small boards or otherwise, once they have taken the first ridging follows soon and they are given the continued care which tobacco growing further entails.

At the time that the first Europeans settled here, tobacco was already grown by the Battak, for their own use. Today also we find them growing the same variety, characterized by the petioles with little or no wings and the smooth stem. The Malay grow a tobacco type which is picked green, then finely cut and dried in the sun. This tobacco, which already shows more similarity to the Deli-tobacco, has however hanging leaves which are strongly wrinkled and not so flat of surface as the real Deli-tobacco. Here, however, the petioles are winged indeed and in addition these wings continue along the stem.

The Deli-tobacco as it is grown nowadays for the European market descends, supposedly, from Java-tobacco seed that in turn would have been hybridized with Manilla-tobacco seed.

In botanical sense the tobacco belongs to the large family of Solanaceae. Following the subdivision of this family by v. Wettstein the Deli-tobacco belongs to the group of the Nicotianinae, genus Nicotiana.[a] This in turn is subdivided into about 40 species, which together are placed in three groups. One of these groups forms Nicotiana Tabacum Don; the Deli-tobacco should then be one of the many cultivated forms of Nicotiana Tabacum L. and hence belongs to the group of Virginian tobacco.

a Von Wettstein after Engler u. Prantl, Nat. Pflanzenfam. Theil. IV, 3 Abth.

In the foregoing pages we saw thus where, how and which tobacco is grown in Deli, and could specify some reasons why just Deli is so suitable to produce this coverleaf-tobacco. After these more general comments we will occupy ourselves with the more special description of the disease that occurs in the nursery beds of the tobacco.

3.2. Occurrence and spread of the bibit disease

Only when a disease in one or the other crop has attained such an extent that practicians become apprehensive about a good harvest, usually one sees that the necessary attention is given to such a plague. To this cause it should certainly be attributed that, when enquiries are made about the first occurrence of a disease, the most diverse data are mentioned.

The same is true for the bibit disease, here too it received no attention at first, when occasionally a few plantlets on the nursery beds died, or even when sometimes entire nursery beds failed, as it was called euphemistically. When the damage increased continuously, people were gradually forced to take this 'failure' into account, and to pay attention to the disease symptoms. Thus, to many it was as if the disease in 1889 suddenly had made its entry. From the Malay [people], who grew tobacco for a longer time, one could however learn that among them the bibit disease, with the same symptoms as today, was known already at an earlier date.

Furthermore, it was heard from some estates that they had to suffer of a same plague already earlier; the years 1878, 1889 and 1892, regarded by some as fatal, drew the attention due to the more epidemic character that the disease then assumed. In 1893 the disease still occurred rather severely, in 1894 is was rather dry, the disease had however anything but disappeared, but people began to apply control measures, continued in 1895, by which a pernicious spread of the bibit disease could be counteracted. When people became first attentive to the bibit disease, it was said that only Deli was affected and Langkat and Serdang remained free from the plague. That this would continue was soon shown to be an illusion.

In 1893 several estates in Upper and Lower Langkat were already affected, Serdang and the coast were then said to be free, but in 1894 this also came to an end. In Lower Langkat one estate, lying rather isolated, seemed to be non-susceptible, until now in 1895 suddenly, according to the manager, the disease appeared in several sections and to a high degree.

Though it is often of not so much significance, nonetheless the whole of Deli and Langkat is infected, i.e. the germs are present as the unexpected occurrence here and there of diseased beds shows sufficiently.

In 1893 the opinion was still such that the disease had only a minor local extent, so that bibit was planted at a rather large scale in the proximity of the end station of the Serdang line of the Deli railways, to be transported later to Deli for transplanting.[10] By isolation it was attempted to keep this reserve-nursery with coolies etc. free of infection from Deli.[11] But in 1893 already the disease could be observed in these bibit nurseries. Though the plague there did not assume such large dimensions as elsewhere, the factors are present indeed to let it grow into a calamity there too.

At a time when Deli's future looked dark and the end of the tobacco culture there was already predicted by some, people at the coast were unaware of any bibit disease and waited only for Deli's ruin, rejoiced to raise the head after all.

This hope soon appeared to be vain because the bibit disease made its entry also in Padang Belagei and did notify how much the foe should be feared lest adequate measures restrain the evil.

From Assahan came only rumours that the disease would be there already, but no certainty thereabout was obtained. If we set this last area apart, then in fact not a single region of the tobacco-growing part of Sumatra's Eastcoast remains uninfected at this moment (1895).

As it seems furthermore that the germs of the disease are already dispersed in areas where tobacco was not yet grown, so it appears to depend only on secondary conditions whether the disease will spread so much that the bibit disease becomes a plague. So much seems however to be certain that wherever tobacco is planted in our colonies one has always to take the bibit disease into account, even if she does not appear immediately in such a stark expansion as now in Deli.

Where tobacco is grown by the natives for the local market, it is in the nature of things difficult to obtain sufficient data and reliable information about the presence of one or other disease and the failure of a crop is usually attributed to causes that surpass phytopathological concepts.

Only there, where European energy occupied itself with a crop, reliable information can sometimes be obtained. Besides on Sumatra one finds tobacco estates in North-Borneo and on Java.[12] According to statement of eye witnesses the same disease as in Deli occurs on Borneo, with wholly identical symptoms. They would have shown up along the Kinabatangan as well as along the Limbatoe, but until now only sporadic.

On Java the disease is better known and under the name 'wedangan' rather feared.[13] Due to the curious cropping method applied there the disease could until now not attain the same expansion as in Deli. Seldom or never so many nursery beds have been laid out together as in Deli, where the people are given a certain amount of seed of which they may grow bibit in the way they think fit. First this is usually done in a rather primitive manner, which as we will see later, can have an unfavourable effect on the spread of the disease, and second, one never knows how many beds fail since, if one sowing sometimes gets diseased, a neighbour or friend will help again with new seed or plantlets. Though until now nothing else is known of the 'wedangan' than the description and the assurance of the Java-planters in Deli, that the disease shows the same symptoms on Java, so there exists nonetheless sufficient presumption to regard the 'wedangan' and the 'bibit disease' as identical.

I believe to have one more argument in the occurrence of the disease at Buitenzorg, where in the 'Cultuurtuin' nursery beds had been laid out and the disease, without infection from Deli, appeared whereas the further study on the site showed that the cause was the same.[14] On Java too the bibit disease is present and it is to be ascribed only to favourable secondary conditions that the disease did not yet expand more.

Though tobacco is one of the most [widely] spread crops and is generally grown in the temperate and tropical zones, we could not find indications in the literature that the same disease with the same cause occurred elsewhere. Though a disease is reported From New South-Wales which there destroys the nursery beds with nearly identical symptoms,[a] the description of the parasite by Dr. Cobb does not allow to decide with certainty whether the cause is the same.[15]

As we will see later the parasite belongs to a generally distributed fungus species and it would bear astonishment if only our Dutch colonies would be ravaged by it. We thus believe to have to ascribe it to conditions as set out above if nothing came to our knowledge of an occurrence elsewhere. This is the more probable because the same parasite is frequently described as dangerous to other plants.

We saw already how the estates are scattered over the relatively narrow coastal strip, how the bibit disease appeared everywhere, without bothering about higher or lower altitude, nor about the various soil types of the estates. Let us now consider the distribution of the disease over the estates themselves.

The disease had already spread too much to point to a certain centre of infection from where the disease spread every year in increasingly large rings. Rather, it seems as if the disease had reigned here and there during a few years, then to disappear for some time again. Facts that would confirm the supposition that the germs of the disease are everywhere and only wait for a favourable opportunity to develop.

However, on an estate, which has in itself a much smaller scope, it is possible indeed to find out where the disease appeared first, how it spreads over older and younger nursery beds and, proceeding from field to field, spreads over a whole section.

When, however, one foremost wants to judge the older data, provided about the appearance, correctly one has to take into account the desire of the coolies to keep the disease secret and to destroy the symptoms as carefully as possible. Before, I already pointed out how the coolies do not fear any effort hereto and sometimes already have removed the diseased plantlets before even the assistant [manager] starts his round. Now that also the Chinese [labourers] come to recognize the danger of such an action, they hasten nowadays to report promptly when suspected phenomena appear.

An estate has usually several, sometimes 4, sections; due to the curious nature of Deli's soil it often happens that the soil conditions greatly differ among the various sections. Where possible, the sections are distributed so that they are laid out partly on still virgin forest soil, partly on soil already cropped earlier. The appearance of the disease happened to be completely independent from one or the other soil type of an estate. Beds on sandy soil as well as on clay or lalang soil were affected and, where it happened sometimes that in one section several soil types occurred side by side, they formed in no way an obstacle to the spread.[16] Only humid soils produced a difference for reasons that will be considered later.

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a Agric. Gaz. of N. South Wales 1893, p. 317.

In the field it was clear that the disease appeared in the nursery beds on old soil as well as on soil where tobacco never had been grown.

It was thought that an isolated situation of the nursery beds might be an effective precaution and thus reserve beds had been laid out here and there in isolated places of the forest; even this measure was not always sufficient to prevent infection. Neither the soil type, nor an isolated position are therefore, in themselves, sufficient to prevent the disease; nor is the age of the beds suitable to stop the destructions by the bibit disease.

With the usual method of lay-out each coolie mostly has made multiple beds, close to each other, and separated only by narrow paths. As new beds are regularly sown every 7 or more days, beds of different ages are close in each other's proximity. Though mostly one of the younger beds was first attacked, one humid night was sometimes enough to completely destroy such a complex of beds of different ages. The most general way of appearance is indeed, that some beds, mostly the younger ones, are first infected; when the spread is not stopped, the most nearby lying beds are attacked and soon the whole complex is diseased; the paths between the beds apparently have no effect. In most cases the infection takes place over the soil. Though the first germs were probably transferred by air, for the further spread this is no longer necessary.

In a single case the evidence, that the wind could blow over the germs, was clear from the fact that first some beds, close together, were infested and later on suddenly some beds scattered here and there. As the location, where the beds had been laid out, was open to the wind at one side only, and later the diseased beds were all situated in one direction, whereas sideward the beds were healthy, it was obvious that the wind had picked up and dispersed the germs. Such a way of dispersal can, however, be observed only rarely, where the natural state of the location of the nursery beds offers such a nice opportunity.

The most common method of dispersal is different and takes place by direct transfer. By the coolie, or other persons, who came in touch with diseased plants, the germs are transferred by hands or cloths to not yet infected places. The same can happen with their implements, tjankols, water casks, and so on.

Mostly one sees that a bed gets diseased first at the edge; then, it is nearly certain that the infection is brought from elsewhere. When several diseased plantlets are scattered, i.a. at the centre of a bed, it is probable indeed that the infection was transferred at least not by the direct influence of man.

Once the disease has made its entry with a coolie, he usually transfers the infection himself, when picking worms and insects, by touching now diseased and then healthy plantlets, if not the necessary precautionary measures are taken. We already pointed out that the paths between the beds are not wide enough to prevent spreading of the cause of the disease over the soil; often it is seen that radiating from one bed the next gets diseased, first at the nearest edge, and then gradually the disease spreads further and further inside.

That in Deli one hears speaking of the bibit disease only during a relatively short period of the year is connected with the method of cultivation since the estates make nursery beds during a few months only. During the largest part of the year there is no bibit and hence no bibit disease, but in her appearance the disease is not bound to a certain season.

So it happened that beds, laid out for special purposes beyond the normal planting time became diseased all the same.

Early in March sowing begins. As long as tobacco is transplanted, new beds are laid out each time; indeed one hears now and then more about the disease on these beds than at other times. In 1893 i.a. an abnormally prolonged drought was prevalent in some parts of Deli, accordingly the bibit disease was less severe and even practically disappeared here and there. However, as soon as a rain shower fell, messages of renewed appearance or spread of the plague arrived promptly. Not so much the absolute amount of water that came down from above had an effect here as indeed the humidity of the air. Several times it was observed that e.g. after a heavy rain shower only little disease appeared, or did not further spread, when a good sunshine rapidly dried the soil. When the sky remained covered and the soil moist, the disease popped up again even after a light shower which sometimes should be considered of no importance in comparison to the downpours.

Earlier already I explained that it has to be ascribed to various causes that in recent years more is heard about the bibit disease than before, also changed rain conditions are often mentioned as a cause. Now it seems indeed that the rainfall in Deli changed. Short heavy showers alternating with lengthy droughts replaced the formerly more regular climate and the frequently recurring mild showers.[17]

Correct data on the relation between rain and bibit disease are, however, difficult to obtain and only suppositions are permitted here, as long as no reliable observations are available here about.

If one wants to make correct rain observations in relation to this point, they should be made on the sections, in the midst of the planted fields; not on the institution that sometimes lies at great distance.

We thus saw in this chapter that the bibit disease is not only found in Deli, but that also elsewhere, on Java and Borneo, the same plague occurs.

It was demonstrated in detail that the whole of Deli is infected and [that] soil type nor location form an obstacle to its appearance. In different years the spread of the disease was not always the same, mainly weather conditions exert influence hereupon. The infectious character of the disease follows clearly from the appearance and spread over all Deli; still easier this could be followed on each estate separately, at a time when people were not yet so much aware of the evil as today and did not yet spend so much effort to control the bibit disease.

Now that in recent years the bibit disease became known, the control on rational grounds was also taken up, with the consequence that many of the situations described belong to the past already. For many estates the bibit disease is no longer a plague that threatens the harvest, thanks to appropriate measures, but only a danger, that can be controlled and restricted within narrow limits.[18]

3.3. Symptoms and characteristics of the bibit disease

The nursery beds of the tobacco show diverse disease symptoms; the bibit disease in Deli, however, is a specific disease characterised by certain symptoms.[19] Since this name enjoys such a sad reputation and is in general use, we have thought it permitted to use this name, which in fact expresses a general concept, for the particular disease of which the description follows here.

Much of what appears in the following pages has been communicated already in the preliminary report in nearly the same wording, the phenomena accompanying its occurrence did not change; hence we may let follow the description in nearly the same words.[a]

The disease is first seen on still young plantlets, with leaflets at most 2 to 3 cm long, by the dirty grey-green colour which the leaf assumes. This shrivels up and when the disease spreads fast it soon changes into a dark-green slimy mass covering the surface of the nursery bed; it looks then as if such a bed has been poured over with boiling water, and quite characteristically chosen is the name 'wedan' for this disease on Java, which indicates the same.[20]

Trying to pull up a plantlet it is involuntarily crushed, leaving a green-slimy mass between the fingers. But only in exceptional cases the disease occurs so heavily, related to exceptionally favourable circumstances for the development of the disease-agent.

In these cases the disease will not be limited to a few beds, but sometimes all beds will be attacked within the span of a single night, the following morning it being difficult to recognize the fresh tobacco plantlets of the foregoing evening in the green mass on the nursery beds.

The saying goes that the occurrence as mentioned above was nearly general in 1892; in 1893 the disease did not appear in such an acute form, though plantlets of nearly the same age and size were attacked, but only in two cases I could witness such a rapid course of the disease.

In later years too such an acute occurrence has been mentioned at times; but this always belonged to the exceptions.

When the disease spreads so rapidly one sees with such young plantlets that usually the leaflet first loses it clear, soft-green colour and shrivels at the edge and gets flabby; when the petiole is also attacked it falls down. In a short time one finds only a translucent film, at last the weaker parts of the leaf are consumed and disappear completely within a few days, and only some fibres indicate where originally the leaf had fallen on the ground.

When the plantlets are larger and more sturdy of built, the bibit disease appears more in the shape of isolated flecks and the whole leaf is not attacked at once. Such flecks can be found on leaves of the most diverse ages, on a leaf of hardly a few centimetres long as well as on completely developed leaves of first length.[21]

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a See Prelim. Report page 9 ff.

So, the development of the leaf has some relation with the mode of appearance of the flecks. It seems that the very youngest leaf, with its week and soft tissue, offers a favourable growth medium to the parasite of the bibit disease, so that there the disease rarely restricts itself to one fleck, but soon attacks the whole leaf.

With older leaves, having more resistant tissue, the parasite has to fight against the resistance of the leaf, the more so when the leaf is older and the tissues are more sturdy. With the younger leaves we see the flecks spreading fastest with the most complete exhaustion of the affected part of the leaf.

In the beginning the flecks are not yet sharply defined, they become first visible as a dark-green coloured centre with margins vaguely running out. Later the heart of the fleck dries up and forms a clear transparent spot surrounded by a dark-green border which separates the fleck from the healthy part of the leaf. On larger leaves the first appearance is the same, there too the central part dries up; this does not become so transparent but takes a more brownish tint which is alternately lighter and darker brown in concentric circles.

These circles are related to the periodical development; it is as if the parasite each time takes a rest to summon strength and then again spreads equally in all directions, a phenomenon that occurs often with leaf flecks.

In the end the centre dries up completely, also with flecks on the larger leaves, and first becomes leathery and finally horny and brittle.

On the large leaves the distribution of the flecks is quite irregular; sometimes they originate near the edge, then again more toward the middle of the leaf blade. In their expansion they are stopped neither by secondary nor by primary veins; these are seen in the fleck as a dark network.

Since the fleck expands rather rapidly, and the infection occurs very easily where the leaf touches the soil, or is in contact with other infected leaves, one finds the flecks on the younger leaf mostly at the edge and mainly near the top, which spontaneously or at watering came in touch with the soil.

This occurrence of the flecks at the edge of the leaf leads, with young leaves still in the period of vigorous growth, to an irregular development, one half growing stronger than the other where the fleck locally impedes the development of the leaf.

So one sees mostly that the young leaflets attacked by the bibit disease have unequal leaf halves and are curled at the top.

Sometimes this is even visible when the leaf is already infected but hardly shows it by discoloration or otherwise.

It is possible to find flecks on the petiole when the leaf blade is yet unaffected. The petiole assumes a darker colour and finally the vascular strands are seen as a fine black stripe in the discoloured tissue.

When the stem of the young plant is attacked, whereas the other parts of the plantlet are still healthy, the part near to the soil is usually dark lead-coloured. The epidermis, which at first is soft, becomes slimy and finally dries into a hard glassy skin.

When this fleck has only little extension, the plantlet keeps standing upright but as soon as the fleck has extended over the whole circumference of the stalklet the plantlet topples over and completely rots away at the attacked spot. Even with plantlets that show already a beginning of lignification this may still happen.

This last symptom is also called kaki-boesoek by the Chinese and it is sometimes considered to be different from the bibit disease which is manifested by leaf flecks. Sometimes it happens, especially when a drought has set in, that the plantlets attacked as described last, apparently become healthy again. The sick spot dries and is difficult to discern, so that these plantlets are often transplanted by unobservant coolies. When later the fleck turns wet again from the soil, that touches it after ridging, the parasite continues to grow and subsequently the larger plant dies.

As this symptom occurs only with older plantlets, with younger [plantlets] the leaf is usually attacked directly, it is always suspect when one sees the coolie pulling up a few plantlets, standing close together, from an older bed. The open spot thus formed allows the access of air to the stalklets at the margin of such a spot and this impedes the spread of the disease. It seems as if the disease has come to a halt but nearly always some of these plantlets are already attacked. It is recommended to destroy, besides the spot pulled up by the coolie himself, a much larger area if not the whole bed. Kaki-boesoek may not be so dangerous, but that is only apparent, and the consequences usually become noticeable later, hence caution is really needed.

In the nursery beds we find the bibit disease as just described; with transplanted individuals in the field, healthy before, the disease can only appear in the form of flecks on the large leaf as described already.

A direct attack on other organs has not yet been demonstrated with certainty; the bibit disease does appear also on plants several feet high in a different form, by which the stalk blackens at the lower end and the bark rots away completely. Always, the infection has already taken place in the nursery beds and the coolie has not used healthy planting material.

The flecks of the bibit disease on the large leaves sometime appear, as it were, suddenly, scattered over a whole section. Possibly, bibit disease did occur in the neighbourhood before, e.g. on the nursery beds of the section and these have been controlled, or the beds were left to their fate and destroyed ineffectively. When the first has been done inadequately, the germs are still present, and these may arrive at the large leaf and develop.[22]

Earlier already we drew attention to the tissue of nearly adult plants that seems to be more resistant, so that it is possible that the parasite has spread within the leaf over some distance before being seen. When this happens during moist weather or covered sky followed by intense sunshine the fleck where the fungus nested dries up and it seems as if suddenly a fleck of several centimetres came into being.

The parasite can be present in the leaf before being visible at the outside as is sometimes shown i.a. with tobacco already carved. When the plant came from the field it looked quite healthy but as soon as the process of drying begins with the accompanying change of colour the fleck becomes visible and finally forms a weak spot on the dried leaf.[23]

There is another way to infect the large leaf. If there is bibit disease somewhere in the nursery beds and in the morning the coolie goes worm picking, he may carry the germs of the disease with him on cloths and hands. Now he goes to look after the large tobacco and transfers the germs. Only a few plants are sufficient to spread the disease further every day; the first infected plants thereupon serve as a source for further infection. This will happen mainly with already large tobacco where the leaves allow but little space between the plant rows. In that case the flecks occur near the tips of the leaves or also on the mid vein more toward the middle of the leaf. The reason is that at the time when the coolie walks through the tobacco the leaves are already limping at their tip. With the occurrence of the disease in this form it can be observed that those leaves especially, that come into contact with the person moving between the plants, get diseased and flecked, the higher leaves are usually healthy.

On several estates it was seen that the infection took place in this way. In one case the large leaves exhibited flecks in a whole section on two non-neighbouring coolie-fields. In the same section the bibit disease had been rather severe, but was controlled successfully as evidenced by the healthy appearance of the tobacco. Upon inquiry it appeared that these two coolies, having had the disease at a low level, later had pulled up the plantlets but without reporting this, because all seemed to end well. Now they stood before their diseased large plants and had to suffer for their carelessness.[24] In this way of occurrence the real cause is the disease on the nursery beds, and the same is true for another mode of occurrence on the large plants where not the leaf but the stalk is attacked. Here again, the infection is transferred in one way or another from the bibit, or with the bibit, or the planting was done on infected soil. As we will see later the germs of the disease may at times remain in the soil for a longer period, when diseased bibit had been on the spot before.

When the consequences of the bibit disease make themselves felt on large plants, the damage is the greater the more the plants are developed; often is becomes impossible to replace the dead plants by filling up, and a large part of the expected harvest gets lost.

When the morning dew has lifted and one walks through the tobacco fields, the plants attacked as meant above catch the eye because the leaves are limp, sometimes only the lowest, sometimes all. A peculiarity herewith is that only the leaves on one side of the plant are limping whereas the others maintain their normal position.

The limp leaves are precisely those that were already sunlit when the others were still in the shade. This symptom indicates that the limping of the leaf is a sign of water shortage which the tobacco plant will show at the least disturbance because the evaporating area of the leaf is so large.

Mostly one finds several tobacco plants together with limping leaf, sometimes these are limited exactly to one or few fields. In most cases inquiry showed that first the plants had been transplanted by one and the same coolie and furthermore that the planting material had been taken either from nursery beds where the disease had already appeared before or from beds in the immediate neighbourhood of attacked [ones].

Pulling up such a plant that shows water shortage, it strikes one immediately how poorly it is rooted in the soil; looking at the stalk it will be found that of the part, covered with soil during ridging, the bark is blackened over sometimes a considerable area and pushed in, as it were. When the disease has progressed far it may be that the bark has rotten away nearly completely, then the roots have also nearly totally decayed, the root bark lets off easily and healthy, normal lateral roots are exceptional.

Besides the bibit disease some other pests occur on the large tobacco plants which manifest themselves by symptoms of water deficit.

Without yet taking recourse to microscopical examination it is pretty certain that, when the stalk is black-coloured at the lower end and the marrow has dried up in platelets, which inside the stalk have the appearance of a honeycomb, the plant died from bibit disease.

In a preceding chapter we already mentioned that the condition of the soil had no effect on the occurrence of the bibit disease; but we have to add some restriction in as far as it became evident that moist parts favour the extension and spread of the disease. There the parasite develops easier and it may thus happen that on boggy soil the bibit disease, from a small spot that was infected somehow, spreads over or maybe also through the soil. In this case the condition of the soil has an effect indeed.

Furthermore the soil itself can be infected. When e.g. the disease has been present in the nursery beds of a section during a year and that piece of land has not been disinfected adequately, the germs survived in the soil.

Especially in the past, when the nursery beds generally ware laid out on a terrain that was planted with tobacco in the same year, this happened several times, and later the large tobacco died, even when care was taken to use bibit as healthy and vigorous as possible.

The germs may remain in the soil even after years without losing their noxious capacity when they resume development. On an estate, where the bibit disease had been rather severe in a relatively small area, tobacco was planted first, which died, and later in the same year rice. Following the rice harvest a lalang wilderness soon appeared which was left undisturbed for two years, without a sign that the lalang may have grown less than elsewhere on that site. When in the third year tobacco was planted on the same land everything died and the parasite of the bibit disease was found in the dead plants. Other plants in the same section remained healthy.

When the infection comes in this way from the soil the plants die in the same way as described above; first we see the symptoms of water deficiency while in the end the marrow dries up in platelets.

Finally another way should be mentioned in which the soil gets sometimes infected.

When earthing up it is customary here and there to take away the underleaf placing it between the plants, later these leaves will be covered with soil. Without ado it will be clear that the soil becomes infected when diseased leaves are buried in this way. The parasite attacks the stalk at the lowest part, and penetrates it to do its destructive work.

For completeness sake it be mentioned that the bibit disease may endanger even cut tobacco. When plants are cut and harvested which at their lowest part are yet little attacked and seemingly healthy, and hung in the drying sheds, the stem turns intensely black in a far shorter time than usual, as happens with healthy plants only when the leaf is nearly totally dry. Here, however, the leaf is comparatively far too moist, and saprophytic organisms, which settle preferably in these diseased plants, spread rapidly and attack the leaf stalks which become 'rotten'. A danger much to be feared when fermenting since at bundling it may pass from one leaf stalk to the other.

Therefore it is advisable, when one finds to have such diseased stalks in the drying shed, to pick the leaves soon, when the leaf stalk is still healthy, and to dry the leaf separately, to keep it later apart at bundling.

That it is furthermore advisable to destroy the diseased, black stalks, preferably to burn them, will be obvious.

Summarising we saw how the disease occurs on nursery beds, how it spreads later and is transferred and attacks the large plants directly or indirectly.

We investigated under what phenomena larger and smaller plantlets died, we saw that the disease can also occur on nearly adult leaf and there can become dangerous. Also we explained how large plants die; what the symptoms are and how the infection can be transferred. How dangerous, mainly for larger plants, a soil infection is (for bibit less as one sees it earlier and can acquire other planting material) and [how it] can remain latent for years. Finally we described how the bibit disease may make itself felt even in already cut tobacco.

3.4. Microscopic examination of the plants attacked by bibit disease

We already described how on the still very young plantlets the first signs of the bibit disease become visible by the grey-green colour of the leaflets, while the flecks are then not yet well visible.

Upon microscopic analysis of such a leaflet a network of fungal threads is found on the leaf's surface. Clear and with strongly refracting wall these threads give a grey hue to the green colour of the leaf.

Here and there one sees a fungal thread penetrating through a stoma, which then further spreads through the intercellular cavities in the parenchyma.

Soon, the chloroplasts lose their clear colour and become nearly completely disorganized; after a few days one finds on and in such a leaflet a rich vegetation of saprophytic organisms which contribute to the further disorganization of the leaf.

The fungal threads, about 5 to 6 μ thick, are characterized by their extremely thin, clear wall which encloses a granulated content. The latter consists mainly of proteinaceous bodies; oil droplets are practically absent. As this granulated matter has the property to retain strong dyes (i.a. aniline-blue) it is easy to make the threads visible by colouring, also inside a tissue.

Besides by their thickness and granulated content these fungal threads are further characterized by the nearly complete absence of septae, so that the thread is unicellular in the botanical-taxonomic sense. Occasionally, part of the contents in one thread are contracted, due to some cause, leaving as it were a partly emptied thread. That part then is separated from the rest by a fine septum. Otherwise the fungal thread, when growing unimpeded, is elongated and only sparsely branched.

The disease appears and is clearly visible mainly in spots where germlings stand close together. In these spots the fungal threads can sometimes be seen with the naked eye. As a fine network they reach from one plantlet to the other and creep on over the soil.

When the disease appeared recently on a nursery bed sometimes only the margins of the leaflets are affected, the remaining part of the leaf, the petiole and the trunklet do not yet show any trace of the fungus, also internally. But when such a plantlet is carefully pulled up from the soil it strikes that the rootlet is brown-coloured and poorly developed in comparison with healthy individuals. The cause of this could not be identified; repeated microscopic studies led to no result.

The stage, during which the fungal threads still have such a small extent, is usually rather brief, the parasite penetrates further and the plantlet dies.

It may, however, happen that for some reason or other the disease comes to a standstill and that, when the conditions continue to be favourable, the remaining leaflets are not hampered in their development. With such a bibit only the lowest leaflets, hanging limp, are attacked, the petiole itself appearing healthy.

When such a bibit has attained the size of normal planting material and is transplanted the plantlet can still carry the germs of the disease within itself. Later, these develop more, penetrate further, and finally kill the larger plants already transplanted.

If the weather is not too moist little more than a thin skin remains of a leaf attacked by bibit disease.

If there is sufficient moisture to allow rapid growth of the fungal threads, and the weather also favours the activity of other saprophytic organisms, the leaf melts as it were into a slimy green mass.

A few days later only rot-associated organisms are found in that green mass, the fungus in turn has decayed completely and disappeared.

As mentioned before it was striking that in 1892 the bibit disease appeared in the younger beds, in the way as just described, leaving a slimy green mass.

The exceptional amount of rain during the planting period of that year and the very humid weather could possibly explain this phenomenon.

In 1892 the rainfall was in February 258 mm, March 127 mm and April 288 mm, whereas the precipitation for these months calculated over twenty years was on average in February 90 mm, March 90 mm, and April 134 mm.

The great effect of moisture on the rapid spread of the fungus was also demonstrated experimentally by placing, on a nursery bed where the disease had appeared, a bell jar over part of the diseased plantlets, by which these plantlets were brought in a more humid atmosphere than the others. A short while later only a green mass was left under the bell jar whereas the other plantlets were diseased indeed, but not by far completely disintegrated.

The heart of the nursery plantlets sometimes can be attacked whereas the other leaves still look healthy. On the face of it the plantlet still looks fresh but upon closer examination one sees that the youngest leaflets, still hiding in the bud, already show traces of the disease. First they are dark-green, soon black-brown coloured, and they have lost their sturdiness. Upon microscopic examination of such a leaflet one finds the same typical fungal threads as described before.

Through the petioles the fungus soon finds its way to other organs and shortly kills the entire plantlet.

With older plants this mode of attack is quite rare. This form of bibit disease is found most with plantlets about one decimetre high. Since neither the trunklet nor the lower leaves showed any sign of disease when the heart was attacked, we have here once more a case in which the germs of the disease had been transported through the air in one way or another and fell down in the heart of the plant.

In a previous chapter we already described how, on adult leaves too, the bibit disease may appear as flecks that in appearance are completely similar to what we found on younger leaf. We indicated already that neither midribs nor side nerves could stop the expansion of the fleck.

For the spread through the vascular strands the possibilities are fewer than in the loose parenchymatous foliar tissue, but it may happen that the fungal threads penetrate into the fibres and vessels either through direct perforation of the walls or through natural openings. Once the fungus has entered the lumen it spreads therein with elongated, poorly branched threads.

Often we observed, examining a vascular strand that ran through a fleck, fungal threads that had found their way already at a rather large distance from the fleck's contours.

In the preceding chapter we described how the consequences of an attack of the bibit could make themselves felt in nearly adult plants, how lack of water and subsequent death are the external symptoms of this. The trunk colours black at the lower end and soon rots away. With nearly the same symptoms the plants die that are planted in infected soil, here too the trunk blackens at the lower end and the plant soon shows all the symptoms of water deficit.

Microscopic examination showed the same fungus in the black spots of the diseased trunks. These threads are found over an already rather large extent in the still green coloured bark near to the diseased part. Coming close by we find the fungal threads in the interior of the cells, sometimes straight across the cell, sometimes several in a bundle filling the cell's lumen. In the wood, where the fibres run closely together without leaving any space and thickened walls form an obstacle to the fungus, she finds her way through the pits and penetrates further inward through the parenchymatous parts of the medullary rays. Especially in a transverse section through a trunk, in the attacked part, this spreading of the threads can be followed clearly.

In the cells of the medullary ray one can always find fungal threads; except for losing their content the cells hardly change, the walls colouring brown only when the stem is nearly completely dead.

The other wood-elements of such an affected part show, however, the onset of disorganization by their brown-coloured sometimes resinous content. When the disorganization has progressed much further large numbers of bacterial colonies can be found in the greater vessels but this is the occurrence of secondary, saprophytic organisms.

In the cambial part of the trunk the fungus finds its way easily, and soon penetrates into the pith where the parasite spreads rapidly.

The intercellular cavities are large, the big parenchyma cells offer food and moisture abundantly, so that the pith is attacked farther than the blackening of the stem lets us suppose.

The pith is formed by a rather loose tissue of thin-walled cells which are soon disorganized, the cells let each other loose, collapse, and shrink into horizontal layers that give the inside of the sick plant the appearance of a honeycomb.

Possibly the intercellular spread of the fungus is related to this phenomenon, that the cells let off so easily.

Where the leaves are implanted on the trunk the coherence of the woody cylinder is interrupted, the tissues of the petiole there join those of the trunk. In a similar way the pith is connected with the parenchyma in the petiole within the circle of vascular strands. Along this way the fungus finds the opportunity to grow into foliar tissues, as happens rather rapidly. Soon the leaf drops off, because the tissues in the leaf axils decay and so a communication with the interior of the plant often comes into being. With earthing up especially this opening is covered with soil and thus an easy avenue is created for the penetration of all sorts of saprophytes.

After earthing up lateral roots often appear which are attacked too and die if they are within the circle of the parasite's spread.

Before, we indicated already how a trunk is pinched in, as it were, on the place of blackening, of which the explanation is to be found in the collapse of the parenchymatous bark elements following their disorganization.

When the fungus has spread gradually and finally has attacked the whole circumference of the trunk, the plant soon dies and the root system rapidly goes rotting.

The foregoing clarifies what causes all signs of water deficit of large plants attacked by bibit disease. Bit by bit all paths conducting water to the leaf-bearing trunk are blocked or disorganized, in the end the whole root system rots away.

When the disease is in the first stage sufficient moisture can still be supplied, when transpiration is moderate, to provide a fresh and seemingly healthy appearance. This i.a. in the morning when dew and morning fog still linger on the field. When it becomes warmer, by dryer weather, or when the disease expands, or when the transpiring surface increases by growth, the leaf gets limp. A proof of this view lies i.a. in the fact that such a limp plant can recover again by topping it very low and so taking away a large part of the transpiring leaf area. Only seldom it is possible to salvage the plants in this way, unless the plant is ripe to be harvested in a few days.

Clearly, with the larger attacked plants the same causal agent is operating as with the leaf flecks, infection will mostly have taken place on the nursery bed, unless healthy plants were planted in infected soil.

In the preliminary report we already indicated how the course of the disease was supposed to be, facts observed in later years always confirmed this supposition, so that in general we can assume the following course of disease.

On the nursery beds the course of disease can be acute, either when the plantlets are so young that they are attacked at once and die immediately, or when the disease appears on the leaf as large brown flecks with dark edge. The disease in this acute form usually attacks the whole bed within a short time and of course no plantlets can be pulled up here to be transplanted. However, it happens that the disease is not so acute, depending mainly on weather conditions.

On the larger plantlets some leaf flecks may then occur, but these seem to be no cause of concern to the coolie, who eliminates these plantlets to use the remaining ones for transplantation.

It may happen also that no flecks, at least no conspicuous ones, appear on the highest and largest leaves and only the lower leaves of the bibit are attacked, which is often difficult to see when the plantlets are crowded. However, especially when the disease occurs on the nursery beds in such a hardly acute form, this carries a great risk for the later crop. The coolie does believe to use healthy planting stock whereas indeed it already bears the germs of disease inside.

Take the case where a plantlet attained the size of ordinary bibit, the lower leaflets are limp already and nearly completely shrivelled up. When these leaflets carry the germs of disease inside, and the petiole does not yet need to be attacked, little thereof can be seen.

Upon transplanting these lower leaflets get in the planting hole and, when the weather is dry, they are kept moist during the first days by regular watering, and finally [they are] covered with soil. The leaflet and the germs were first in a relatively dry atmosphere, but now this has changed and the fungus finds sufficient moisture to develop.

The fungal threads penetrate deeper and deeper and after all reach the trunklet, that so far grew normally, increasing in length and girth.

The fungus now penetrates the tissues of the trunk, precisely in that part which was covered by soil during the successive [rounds of] earthing up. Accordingly, the disorganization and blackening of the dying plants begin at the lowest part of the trunk.

Other facts become easily explainable as i.a. why the death of large plants is sometimes limited to the fields of one coolie or one kongsie. In that case the coolie did not adequately check his nursery beds and used diseased planting stock or, when his stock was exhausted, he obtained it from another one whose beds were diseased.

Just as the bibit disease appears kongsie-wise in the nursery beds, so will the dying plants in the fields of course appear kongsie-wise. Furthermore, the more or less intense wetness of the soil will obviously be of great influence on the spread of the fungus and hence on the death of the plants.

Thus we see the attacked plants succumbing soon on moist marshy ground.

Thus it may happen in a hilly section that with one coolie the plants die shortly after transplanting whereas this occurs much later with his neighbour who planted on higher ground.

This explains that after continuous rain and wet weather several plants are seen to succumb suddenly, as it were, during a subsequent drought. During the rain the fungus had ample opportunity to develop in the moist soil and now that with the clear sunny weather the plant must use more water again, it cannot be supplied since the tissues are attacked. Sometimes it even happens that the plant itself does not yet suffer the consequences of the disease because the fungus could not yet penetrate far enough to cause damage. Finally the lateral shoots, the so-called tunases, suffer the effects when by the rotting away of the mother-plant food can no more be supplied.

Resuming the results brought to light by the microscopic examination we found everywhere in the young plantlets, in the young leaf and older leaf, and also in the tissues of the stem, a spreading fungus. Everywhere recognisable by the robustness and the dimensions of the threads it is distinguished from other fungi by the lack of septa and the curious shape.

Spreading mainly through the intercellular network of canals this fungus penetrates here and there the interior of the cells and so works its way through the tissues of the plants.

Some very rare cases excepted an attack by the fungus causes the death of the plant. Sometimes it may, however, take quite a while before the symptoms of the disease catch the eye.

3.5. Phytophthora nicotianae nov. spec.; Occurrence, life history etc.

Up till now we only discussed a fungus, which we considered to be the real cause of the bibit disease, in general terms. In this chapter we will try to know this fungus better in occurrence and life history.

The mycelium threads are rather considerable in size, where they grow over the epidermis of a leaf the average thickness is 5 mikrons. Within the cells or in the intercellular spaces we find the same sizes. At times, the mycelium swells suddenly to form thickenings that may attain twice the normal size.

Without septa the mycelium threads extend over large distance when they can spread undisturbed. In the intercellular spaces, however, frequent branching occurs, as when the mycelium grows under water. Often there are several short side branches close together.

These side branches usually are somewhat swollen and filled with a finely granulated content. Sometimes these swellings are rather local and, succeeding each other shortly, then give the mycelium thread the appearance of a rosary (see fig. 9) [= fig. 3.2 drawing 9, p 99].

When the mycelium is placed in water with a leaf fragment, the mycelium threads soon spread in the water and hang down in flocks, and it is mainly on these threads that these swellings are formed easily.

The cells, which border the intercellular spaces in the parenchymatous tissues, have their walls sometimes covered with mycelium that here has assumed a curious form (see fig. 12). Ramifications succeeding each other shortly spread over the cell wall closely joined together and only at their tip they bend away from the common stem, forming as it were a mycelium flock, which apparently has fastened itself sometimes in the wall, and with the tips of the threads drills through the cell wall here and there. If such a mycelium mass is removed from the cell wall at sectioning, the mark on the wall remains clearly visible.

Where the mycelium extends in the lumen of a cell usually short, unbranched threads are formed, protruding straight on, which connect with the mycelium in the neighbouring intercellular spaces by a small constriction.

The wall of the mycelium threads is crystal-clear, rather thin and without thickenings.

The mycelium threads thus are unicellular, only when through external influences, or otherwise, the threads lose their content locally, or are torn up, the content may be separated from the environment by a fine septum.

Earlier we saw how the threads can spread from one plant to the other as a spider's web, now it happens frequently, either by desiccation or due to other reasons, that these threads, hanging free in the air, lose their content, which contracts in those parts directly in contact with the leaf. These parts are then ligated from the remaining mycelium. The loss of content in these threads can already be seen with the naked eye by their silvery shine, whereas the healthy normal threads do not reflect the light so strongly.[a]

The content of the young mycelium threads is finely granulated, without oil droplets, filling the thread completely; in the older threads the content becomes coarser and more and more foamy, oil droplets being rare. With potassium iodide the content of the threads coloured dark-brown and it appeared to be mainly of an albuminous nature. Where the threads lie against the cell wall the content also becomes more foamy and only at the tips finely granulated. Where they branch in the cell by way of haustoria the content is finely granulated too, filling the thread completely.

The normal way of spreading of the mycelium is upon the epidermis of the leaf until it penetrates through a stoma and continues its spread in the intercellular cavities.

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a Compare: Rabenhorst Kryptog. Flora, Vol. I Part IV, pag. 384.

It is, however, possible that the mycelium thread finds its way to the interior of the cell straight through the epidermis, so we see (see fig. 7) a thread producing an extension at a. The thread itself is coarsely granulated but the part that has penetrated into the interior of the cell is filled with a clear content with a fine wall and of considerably smaller size. We see here that the thread does not immediately bend down at right angles to bore through the cell wall, but first forms a heel-shaped extension. It is not improbable that its purpose is a more solid attachment of the thread to the epidermis. This curious shape possibly results in the function of the tip as a suction cup in order to overcome the resistance of the epidermis to perforation more easily.[a]

With a single word we already mentioned that the wall of the parenchyma cells can be pierced too. Usually, however, the mycelium passes through the intercellular cavities. See fig. 1. In the figure we see thread *b* going through this space and branching; at * a part of the wall has remained which, however, does not completely close off the intercellular spaces but leaves an opening through which the thread can proceed to the next intercellular space.

The remainder of the wall was taken away during the section as was the cell wall at *a* through which a mycelium branch passes. The process of perforation is seen in fig. 10. The tip of a thread touches the wall and is somewhat pushed back at the attempt to perforate it; when finally a fine opening has appeared, the tip of the thread forms a fine elongation which presses itself through toward the interior of the cell whereupon it swells soon to its normal width.

Thus the thread is not pressed against the wall in a special way, the curving at the tip proving the looseness of the connection between wall and mycelium. How the wall perforation itself comes about is uncertain, possibly the wall is resorbed and dissolved locally.

It seems that the mycelium exerts a dissolving effect on the wall as a.o. might be witnessed by the curious mycelium shape described earlier. See fig. 12. After removal the imprint of the thread remained and here too the tips of the threads perforate the wall.

Mostly the mycelium threads run free along the wall being easily drawn away from the intercellular cavities upon sectioning.

Hence feeding occurs only there where either the threads proceed into the interior of the cells, or maybe also at the sites where the mycelium is firmly stuck to the wall.

Here the haustoria are not much different in shape from the normal mycelium and only recognizable by their blind ends in the interior of the cells and their occurrence in nearly constant places in nearly constant shape.[b]

Nowhere it could be observed that the presence of the fungus caused uncontrolled cell growth or thickening of the cell wall.

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a Compare: Myoshi Pringsheim. Jahrb. 1893 and Büsgen, Bot. Zeit. II Abth. 1893 pag. 62.

b Compare: Tubeuf, Pflanzenkrankheiten, pag. 17.

Only symptoms of disorganization, as a brown discoloration, of the cell wall made themselves known as consequences. In a foregoing chapter we pointed out how the pith of older plants contracts into plates that separate in horizontal layers. These plates consist of shrunken and dried cells that come loose from each other. Possibly a relation exists between the ease of cell loosening at drying up and the resorbing influence of the mycelium threads.

Tubeuf (see Pflanzenkrankheiten) divides the parasitic fungi into two groups recognizable by their appearance and the way they attack the plant. One group he calls the epiphytic parasites, the other endophytic parasites. The description will have made clear that the fungus of the bibit disease belongs to the latter group, that is to the endophytes and well to those endophytes whose mycelium grows between the cells, in the intercellular spaces, and feed by means of haustoria.

Usually the mycelium as observed with the diseased plants does not produce reproduction organs; apparently these originate only under special conditions, where moisture is the major factor.

However, without reproductive organs the mycelium is still able to spread. As we have seen parts of a mycelium thread can be cut off and these parts can further develop, each for itself.

Out of itself already the mycelium thread divides off such fragments here and there and often it will happen that upon touching a diseased plant some mycelium sticks to the cloths or to an implement. Transferred in this way to a healthy plant these mycelium fragments may in turn become a source of new infection.

Submersed in water the mycelium forms many, short, much swollen parts that can be detached easily and transported along. A few times the fact could be stated that diseased plants of an estate thrown into a stream had contaminated the water of a lower estate, in all probability by spreading in this way. Most frequently we see an infection by direct transfer, in comparison spontaneous infection is relatively rare.

When we place a leaf fleck of an attacked plant in a moist atmosphere we see the mycelium soon forming reproductive organs. The mycelium running near to the surface bends outward, usually finding its way through a stoma, but sometimes also straight through the epidermis. The thread raises up perpendicularly and forms a swelling at its tip which soon becomes pear-shaped and continues to increase in size. The thread itself is completely filled with a finely granulated mass which also fills the swelling. In the beginning the thread is unbranched, later side branches appear. These in turn grow and swell at their tip, where they form the reproductive organs.

When the swelling at the tip has attained its definitive size the conidium thus formed separates from the conidiophore. The wall begins to thicken, becomes clearly refractory and at the tip of the conidium appears a clearly coloured site which through local thickening of the wall forms a small protrusion that easily catches the eye because of its strong light refraction, the so-called mucus plug.[25] Due to this mucus plug the ripe conidium maintains is pear shape. See fig. 3.

The content of the conidium now becomes more coarsely granulated, and finally differentiates into a certain number of spermatozoa. When these have attained maturity the mucus plug becomes fluid at the tip of the conidium and so an opening appears through which the spermatozoa or swarmspores come free. See fig. 11.

It will be clear that this can occur only in water and [that] the availability of an adequate amount of moisture is a first requirement for the development of the conidium and the spermatozoa.

When the conidium has arrived at the peak of development, the conidiophores in the meantime having emptied, it is separated from the remaining mycelium by a wall.[26] Mostly, each conidiophore carries only one conidium see fig. 4, but more [conidia] of different ages can grow on the same conidiophore, one after the other. In fig. 11 we find a mycelium thread depicted where, under the already completely ripe conidia, young ones begin the appear. In fig. 4 we find a not yet fully mature conidium with its bearer which, where it leaves the stoma, seems to cling firmly to the epidermis by means of some protrusions at *a* and *b*. The mycelium thread here is somewhat branched, carrying a still young conidium at its top. The mean length of a conidium is 36 microns, the width 25 microns, whereas the diameter of the conidiophore equals that of the common mycelium.

It seems that, sometimes, a conidium does not attain full ripeness but instead of forming spermatozoa produces a new mycelium thread, which in turn produces a conidium at its top which does attain ripeness.

The content of the first conidium is then gradually digested by the second, and in the end the plug appears at the tip and so an empty vesicle comes into being. Sometimes such a conidium can produce several secondary conidia. See fig. 13 and fig. 14.

Before the content of a conidium begins to differentiate, the lower end of the bearer is closed and the slime plug appears. The content now first becomes coarsely granulated, soon more and more spermatozoa become visible which soon get their own wall, then the plug which kept them enclosed within the conidial wall turns slimy and the spermatozoa or swarmspores come out.

The first moment of their liberation they are yet kept together by a clear slimy mass which soon runs. Practically at the moment the spermatozoa can roam about in the water.

From the time at which the finely granulated structure of the conidium changes until the moment the spermatozoa are set free 20 to 30 minutes go by. The spermatozoa apparently do not originate in fixed numbers within a conidium, at times 10 were counted, sometimes 12, and 15 is about the maximum.

After the short moment that they linger in the slimy mass they suddenly come to life and roam around by means of a long and fine flagellum. Maybe there is another flagellum but this could not be observed with certainty.[27]

During their movement the spermatozoa continuously change their shape, sometimes as round as a ball and then ellipsoidal or pear-shaped. They increase slightly in size, the granulated mass inside later separating and giving room to a vacuole. Thereupon the spermatozoon retracts its flagellum, settles and forms one or more germination threads see fig. 5.

Usually there is only one germination thread, sometimes more.

These spermatozoa may in this way, when they find enough food for further development, lead to the formation of new mycelium. It is also possible, though apparently rather seldom, at least it could be seen only rarely, that a new conidium is formed with the content of the spermatozoon. See fig. 5.

In the figure we see that the spermatozoon first forms several germination threads, on one of these appeared at last one conidium looking like a normal conidium in every respect but of much smaller size.

Whether this conidium formed spermatozoa again could not be observed as it remained in the same state for several days and then died. From the release of the spermatozoa to the formation of this secondary conidium three days elapsed with a culture in a hanging water droplet.

Furthermore figure 5 shows that the spermatozoa have their own wall since this stays behind empty.

Later I succeeded once more in observing a spermatozoon that formed a secondary conidium which opened after four days, the slimy plug disappearing and the content too. Hence it is probable that here again secondary spermatozoa had been formed and that here the complete formation of conidium and spermatozoon was repeated immediately without the preceding formation of a vegetative mycelium.

The formation of the conidia and spermatozoa is completely similar to the description of Phytophthora by de Bary.[a] There he also states to have seen how a conidium that, having already formed swarmspores, is empty, is as it were drilled straight through by a mycelium thread, something very similar to the case shown in fig. 13. Never a connection could be seen between the thread at one end of the conidium and the conidiophore. The release of the swarmspores in one common mass before they go roaming about shows great similarity with what can be seen with Pythium, but there they come forward surrounded by a vesicle which continues to exist after their release.[28]

Thus, the fungus of the bibit disease shows most resemblance in her formation of conidia to Phytophthora omnivora, de Barij, also and especially with regard to the habitus of the conidiophores, which lack the swellings under the conidium so typical of Phytophthora infestans.

Besides this asexual reproduction there is also a sexual one, where oögonia, antheridia and oöspores are formed.

The oögonium may appear at any arbitrary place of the mycelium, mostly we find it at the end of a short mycelium branch, where the first onset of the fruiting body becomes visible as a globular swelling. Intercalary as well as sidelong we find the same shape of swelling with some threads, these swellings later become oögonia. This formation of oögonia occurs only with strong mycelium threads that grow vigorously. The finely granulated content continues to fill the globular

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a Botan. Zeitung 1881.

swellings. With the steady increase in size of the young oögonium the wall becomes more clearly visible, being slightly thicker than the wall of an ordinary mycelium thread. See fig. 6.

The oögonium now separates from the mycelium thread and forms an independent organ. Simultaneous with the swelling of the oögonium a small extrusion appears on the mycelium thread which gradually lengthens, to suddenly bend at right angles at *b* and to attach itself to the oögonium (ready to be fertilized). The antheridium is not yet separated from the other mycelium and still completely filled with the same content as the oögonium and the mycelium thread to which both are connected.

In a later stage only, shortly before the moment of fertilisation, a fine separation wall is formed just below the right-angled bend, whereas the oögonium already separated from its bearer.

Now all content disappears from both mycelium branches. See fig. 15.

First the antheridium attaches itself firmly to the oögonium wall and exerts such pressure that the wall is pushed in locally. Finally a perforation takes place; the pressure is ended and the content of the antheridium can freely pour out into the oögonium.

As soon as this perforation has taken place the antheridium gets a fine needle-shaped extension that penetrates into the oögonium, ending there with a very fine pore. When the antheridium pours its content over in this way, the oögonium covers itself with a firm wall and the content withdraws gradually from the periphery. See fig. 15.

When the fertilisation is finally finished the oöspore or eggspore covers itself with [an] own wall and thus it is now situated within the original oögonium wall. Both are strongly light-refractory with a somewhat bluish sheen. Usually the antheridium now breaks off, near to the right-angled bend, sometimes also the oögonium bearer comes loose from the other mycelium, in this way setting the oöspore free from the remaining mycelium.

When the fertilisation is completed the antheridium has poured over all its content, originally present in *c* (See fig. 15), into the oöspore. At *b* fig. 15 a ripe oöspore is pictured, the content has become coarsely granulated, here and there with strongly light-refractory grains, and encloses a vacuole. Both the oögonium wall and that of the oöspore are clearly visible, the oöspore lies nearly free, only the beak of the antheridium through which the fertilisation took place, interconnects the parts and always remains visible as a fine pattern on the oöspore.

Only toward the time that the oöspore begins to germinate the wall bursts, releases the oöspore and then collapses.

In this way, just communicated, the fertilization process usually proceeds, [but] the formation of the antheridium is also commonly found as a side-branch of the oögonium stalk.

Sometimes it happens also that a fertilising antheridium is formed by another branch of mycelium, completely independent from that which formed the oögonium.

Among the many oögonia observed never more than one antheridium could be found that participated in the fertilisation process. Neither could a case of apadrie be observed;[29] where it sometimes seemed to happen it always could be seen that the antheridium, maybe faster than usual, had performed its functions; from the remnants of the beak the former presence could be deduced.

The oöspore or eggspore remains, apparently, enclosed within the oögonium wall during a considerable period and only toward the time, that it will germinate, the oöspore is released.

A few times only it was possible to let the oöspores germinate without long interval (see fig. 8.); a branched germination thread appeared that can grow out again into a normal vegetative mycelium. The eggspores mostly remain in a resting phase for a considerable time during which they can be exposed to a rather large variation of moisture and drought without losing their germination capacity.

When recently formed oöspores are placed in pure water they seldom germinate immediately. The enclosure of the oöspores within the oögonium wall during a considerable period certainly contributes to an even better protection against harmful external influences.

The description shows that oögonium and antheridium may thank their origin to the branches of one and the same mycelium thread.

Hence a single mycelium thread is able to produce them and thus we find them, under favourable conditions, inside the attacked tissues, in the intercellular cavities as well as in cells to which only one mycelium thread forced an entry.

Thus the course of oöspore formation and fertilisation is here the same as with most other Peronosporaceae; but we must emphasize once more the curious shape of the antheridium.

We have seen already that sometimes the antheridium appears simply as a sidelong extrusion of a mycelium thread running in the neighbourhood of the oögonium and not as a branch of the little stem thereof.

The phenomenon of fertilization then rests here on a modified copulation, i.e. modified in the sense that not two threads produce sidelong extrusions that copulate, but that here the two threads carry a differently shaped copulation organ, and the thread does not continue growth after the formation of these organs.

The textbook of botany by Strassburger states that with Pythium the whole content of the antheridium passes into oöspore, with Phytophthora only partly and that with Peronospora the antheridium beak remains closed.[a]

De Bary[b] also states that only part of the content is transferred with Phytophthora. According to our observations the content of the antheridium becomes somewhat more coarsely granulated before being poured into the oöspore and maybe separates into a 'granulated central and a peripherous water-clear part', as described in Strassburger l.c.[30] We could not see whether something might stay behind.

a Lehrbuch der Botanik v. Strassburger 1894. Pag. 295.

b Bot. Zeitung 1881, pag. 591.

The shape of the antheridia corresponds best with the picture by de Bary l.c. Pl. V. fig. 4., there too we see the heel-shaped extension of the antheridium.

At the onset of the study only conidia and swarmspores were found as propagation organs on diseased plants in Deli. Later in Buitenzorg germlings of tobacco died under exactly the same phenomena as in Deli, but only the sexual form of the reproductive organs was encountered. Originally it was thought that the two cases dealt with different parasites, a Phytophthora-species in Deli and a Pythium on Java.[31] Later, continued research indicated that these two kinds of reproductive organs could be the product of one and the same fungus and that their relationship could be demonstrated repeatedly, be it that the conditions leading to eggspores or swarmspores partly remain in the dark.

On diseased plants which showed the black discoloration at the lower end of the trunk, already described, conidia were found at the outside of the attacked place whereas inside the tissue oögonia were observed; the mycelium of the two forms was exactly the same.

On a nursery bed with healthy plants only, these were sprayed with water containing finely divided leaf in which conidia-bearing mycelium had spread. Twenty days later several plantlets began showing the disease by black discoloration of the lower end of the stems, where the infection had taken place at the site of the dropped petioles. Tissue fragments of these diseased plantlets placed in water formed a mycelium which produced oöspores. A culture made from mycelium forming oöspores continuously finally produced conidia too and at the same time also oögonia.

Later the same [result] was obtained again with a large amount of seedlings that became diseased under the normal phenomena of bibit disease. A mycelium, developed from one plantlet placed in water, produced eggspores as well as swarmspores.

Finally another experiment be mentioned where diseased leaf placed in water gave mycelium producing oögonia only, in well closed tubes this mycelium was brought together with healthy, intensely washed leaf. Three weeks later the mycelium, which had formed, produced conidia mainly.

These culture experiments have not been done under the requirements needed to obtain assurance that an infection was excluded with absolute certainty. As long as it is not yet possible to culture the fungus adequately, taking everything into account that possibly could cause infection, we may consider the above evidence as fairly satisfactory already.

Not only the mycelium is completely identical in external properties and shape, whether they form eggspores or swarmspores as reproductive organs, but also the phenomena evoked on the tobacco bibit are so completely the same, that it cannot be stated a priori, when the disease begins to show, which kind of reproductive organs will be formed. Furthermore it is remarkable that on the tobacco nursery beds at Buitenzorg, where infection with germs brought from Deli was completely excluded, sometimes conidia-forming and at other times oögonia-forming mycelium occurred.

It is not impossible that the time of observation contributed to the separate occurrence of the different forms. In Deli the disease was always studied during the months April to July, while during this period of the year the occurrence of the disease at Buitenzorg could not be observed, and there the disease was studied during the months August to February.

In addition, Del and Buitenzorg have a rather considerable difference in climate which possibly is not without effect on the mode of reproduction.

Describing the formation of conidia and oögonia we mentioned already that the former appear at the surface of leaf or stem, the conidiophores standing perpendicular to the substrate. Conidia were never found to be formed in the interior of tissues, but in contrast oögonia were. A first requirement for the further development of the conidia is moisture; without moisture the conidia cannot open, the slime plug at the tip cannot run out, the swarmspores cannot be released. Only in water the swarmspores can move about, germinate, and form new mycelium.

The oögonia on the other hand need far less moisture for their development, need practically no water to stay alive, and even can support a rather high degree of desiccation without losing their vigour.

In the acute cases, where entire beds with young seedlings die, the conidial form was always encountered; at its surface the leaf was sufficiently wet by ample spraying and humid covered sky to allow the swarmspores to spread and thus to let the infection progress.

We have seen already how, within a rather short period, new conidia can be formed and swarmspores can ripen again. When the conditions are favourable the disease will, in a short time, have spread over a large extent, where the fungus itself takes care of the locomotion and can spread by means of the swarmspores without the need for continuity of the mycelium.[32] This is not so with the oöspores for which the fungus mainly relies on a passive way of dispersal.

This [oöspore] can support a rather hard-handed treatment without being damaged because of the oögonium wall, which keeps protecting the oöspore, and of the oöspore's own wall.

Firmly attached to some object the oöspore can be easily transported without being damaged by desiccation; when later the oöspore comes in a moist atmosphere again, she will germinate and further develop.[33]

In the beginning we described how, with the tobacco cultivation as done in Deli, an infected piece of ground may be fallowed during many months without losing its infectiousness. So it was mentioned that on one piece of land the same bibit disease appeared once more after some years. Meanwhile the soil had been covered by padi and alang-alang, both plants not attacked by the fungus. It is probable indeed that just here, due to its ability to form oöspores, the parasite could continue to exist; the swarmspores would have died during the periodical drought and intense sunshine to which soil and vegetation were exposed.

We could make a similar observation on soil brought from Deli to Java in a crate with diseased bibit. The bibit had died on the way and the soil had no longer been moistened, nonetheless it came out later in Buitenzorg, when the soil was wetted in an attempt to grow bibit on it again, that the germs of the bibit disease had not died.

It would have been too conspicuous to consider this a case of so-called spontaneous infection since accidentally all other bibit in the immediate environment stayed healthy.

These two modes of propagation carry one of the greatest dangers of the bibit disease. The conidial form is, as it were, intended for active self-spreading and for immediate development.

The form with oöspores, often transferred unconsciously, can remain latent for a considerable period before the development starts again.

To investigate how far external conditions affect the germination capacity and development of the eggspores and swarmspores several experiments were performed, reported later. First we consider where the parasite of the bibit disease belongs, according to the description above, and which place we should give her in the taxonomic system.

The single-celledness, the way of mycelium production and of multiplication immediately call to mind the family of the Peronosporaceae. De Bary, founder of this group, distinguished primarily three groups, i.e. PYTHYUM, PHYTOPHTHORA and PERONOSPORA, together with a few smaller genera. Rabenhorst divided the family into two sub-families, the *Planoblastae* and the *Siphoblastae*. In view of the propagation by conidia and swarmspores the fungus fully fits the first group.

The content of the conidia goes out in a slimy mass but not in a vesicle in which first the swarmspores are formed.[34] As the conidia are not arranged in chains but placed on, sometimes branched, conidia-bearers the best agreement exists with the genus Phytophthora.

Also, the description of Phytophthora by Saccardo agrees completely with our findings about our fungus.[a] De Bary combined several parasites, which before were given different names according to their host plants, as *Phytophthora omnivora* de Bar., (*Phytophthora cactorum C. et L.*). Slightly different in appearance, de Bary proved their identity by infecting plants with analogous Phytophthora-species, taken from other plants, and thus demonstrated, by inciting completely similar phenomena, that it was always the same *Phytophthora*.

The *Phytophthora* attacking the tobacco is also able to incite the same phenomena with various other plants. In the vicinity of diseased nursery beds, or on the site where these had been, species of *Amaranthus* were found repeatedly [being] attacked by the *Phytophthora*. Young plantlets of *Androng*, often occurring as volunteers on abandoned tobacco fields, frequently show leaf flecks where the mycelium of *Phytophthora* occurs in the tissues.[35] Not only microscopic examination brought the identity of the parasites to light, but the fungus, which developed strongly when the diseased leaf was placed in water, also successfully infected healthy tobacco leaf and evoked the same symptoms as with direct attack.

a Compare Sylloge Fung. Vol. VII p. 237.

To our disappointment it was not possible to check whether plants, mentioned by de Bary as susceptible to *Phytophthora cactorum*, are also attacked by the *Phytophtora* occurring on the Deli-tobacco. Three species of *Phytophtora* are known up till now, according to Saccardo, *Phytophthora cactorum* (*C et L*) whose conidia are 50, 60 or 90 mikrons long and 35 or 40 mikrons wide; *Phytophthora infestans* (*Monk*) 27-30 mikrons long and 15-20 mikrons wide, and the recently described *Phytophthora Phaseoli*. (Thaxt) where the length is 35-50 mikrons and the width 20-24 mikrons. For the length of the conidia we found 36 mikrons and width 25 mikrons, these measures conforming most to the latter *Phytophthora Phaseoli*. However, as long as the biological similarity of the two fungi has not been demonstrated by culture experiments, we may give the parasite occurring on the tobacco plant the name *Phytophthora Nicotianae nov. spec.*

3.6. Culture-experiments with *Phytophthora Nicotianae*; influence of moisture and drought, light and darkness on the development.

Repeatedly it was tried to grow the *Phytophthora Nicotianae* on some culture medium in order to study the developmental history and some other questions in detail.

The same has been already attempted with other Phytophthora species, always with a negative result. Such was also the case with our experiments. We have seen in passing that the fungus grows readily in water. When fragments of an attacked leaf or plantlet are placed in ordinary pure or distilled water, a few days later the mycelium can be seen hanging down in tufts from the floating leaves, which decay rapidly into a green slimy mass containing numerous fructifications.

Mycelium yielding only sporangia as well as mycelium producing oöspores grew excellently in this way, the content of the fungal threads seemed more finely granulated than usual, and often swellings occurred at the tips of the mycelium threads hanging down in the water (See fig. 9). This rapid and stark development of the mycelium is a rather easy means to decide, in dubious cases, whether the attack is by *Phytophthora Nicotianae* or another cause killed leaf or plant. Part of the fleck or diseased stalk is placed in water and some fragments of healthy leaf are added; if the *Phytophthora* is present this will appear soon as a long flocky mycelium and where contacting healthy leaf [it will] attack this too. First, brown flecks appear and soon the healthy leaf decays into a green, slimy mass.

Perhaps unnecessarily it is recommended to place some healthy leaf in water without diseased plant parts as a control. The leaf, not infected by *Phytophthora*, will remain fresh and green for a considerable period.

Mycelium placed in water separately, by e.g. cutting off a part of such mycelium hanging in water, will further develop, but only so that the content of the threads withdraws steadily into the newly growing parts and hence feeds and grows at the expense of the older, dying parts of the mycelium.

The question now was whether by adding some nutritive compound to the water the development of the mycelium might be furthered. Fungi readily accept cane sugar as food, therefore it was tested whether the *Phytophthora* would develop stronger than in ordinary water by the addition of 5, 10 and 15 % cane sugar.

Oöspore forming mycelium was added to the solutions.

During the first days the mycelium grew best in 5 % sugar-water and formed numerous fructifications but after some six days it remained stationary. The cultures in sugar-water of 15 % were quite poor, the threads thinner than usual, and the content with more oil droplets than in healthy threads.

With some threads an intercalary separation of round, small cells occurred, without fructifications, and hence it seems as if this yeast form (?) takes care of the survival under unfavourable conditions.[36] In sugar-water of 10 % the development was better, the threads were healthier and thicker and oöspore formation took place but not so numerous as in 5 % sugar water. Conidia-bearing mycelium was also brought in 5 % sugar-water; during the first days numerous new conidia developed and the spermatozoa germinated with long germ-thread. The conidia were submerged in the fluid; possibly as a consequence some spermatozoa were found that stayed within the sporangium wall and germinated there, the slime tuft had disappeared and at that place the germ-threads came outside. That the conidium formed germ-threads even before the zoöspores had been formed, could not be observed.

A decoction of prunes, which is a good nutrient medium for several fungi, in which they grow readily, gave a negative result.

Tobacco foliage was burnt and the ash extracted with water and diluted, [but] the *Phytophthora* could not be induced to grow herein.

Mixing agar-agar and gelatine-peptone in various ways and a decoction of leaves it was tried to find a suitable solid nutrient medium for the *Phytophthora* but nearly always with nearly negative result; the *Phytophthora* developed not at all or very slowly to die soon.

Some threads were taken from a mycelium mass that had spread over germlings of the tobacco and transferred to sterilized potato disks, in the beginning this culture was fairly successful. The sites, where the *Phytophthora* grew profusely through the tissue, coloured red, the walls showed gummation and the starch disappeared. The mycelium spread inter-cellularly but died after a few days. This culture was most successful yet when the infected potato disks were placed in the dark.

It was tried to repeat the same type of culture on sterilized banana disks but the mycelium could not be brought to fructification or to good development.

To follow the development under the microscope, cover slip cultures were made in hanging drops of water or of 5 % sugar-water which usually succeeded as hoped.

From an earlier description we remember that in the open field an acute attack usually occurred at night, just as the disease could be far more severe under dark-covered sky. Though without doubt the higher humidity had the greatest effect under these conditions, it could be so that the reduced light intensity exerted a favourable influence on the development of the *Phytophthora*.

The problem was the correct performance of the experiments, when determining these factors. It was difficult to always use the same number of germs and, as the experiments were done with leaves in water, the distribution of the germs in the water, of course, affected the decay of a larger or smaller amount of leaf, in accordance with the number of infection sites being larger or smaller.

It seemed as if mycelium formed long-drawn-out threads and fewer propagation organs in the dark.

Old as well as young leaf, infected in the same way with oöspores or swarmspores, seemed to be consumed much faster in the dark. Leaves placed in the dark had decayed completely to a green slimy mass after three days already, whereas pieces of the same leaf exposed to daylight then only showed brown flecks.

The effect of moisture on the development of the fungus was shown i.a. already with the water-cultures, and naturally the question posed itself with these experiments how much drought and desiccation the swarmspores or eggspores could bear. The a priori expectation is that sporangia and swarmspores could not withstand desiccation. Perhaps unnecessarily conidia were applied to a cover slip and stored dry during one day. Upon moistening and examination all of them showed to be dead, the content had contracted and the swarmspores no longer wanted to germinate.

Oögonia protect the eggspores by their wall and make them more resistant to drought; but a continuous drought of fourteen days sufficed to kill them. Oögonia dried together with the foliar mass and stored air-dry could still germinate after some days; but when the foliar mass was exposed for two days to direct sunlight, during five hours a day, all germs died after this sunbath.

If subsequently the foliar mass was put in water together with healthy leaf, no more development of mycelium occurred.

Whereas drought, in the long run, certainly is damaging, direct sunlight kills the germs of the bibit disease nearly instantly.

At a larger scale the same experiment was repeated on a nursery bed.

The tobacco seedlings were rather regularly distributed over de nursery bed so that four equal sections could be designated, of which two were constantly in the shadow and the two others were exposed to the direct sunlight. These four sections were infected by spraying the first and third sections with water that contained swarmspores, whereas the second and fourth section were infected in the same way with eggspores.

The weather had an unfortunate effect on the result of this experiment because the first few days after infection the beds had to be well covered in view of the heavy driving rains.

The disease appeared first in the two sections infected by swarmspores, but at very low intensity in the section exposed to sunlight.

One day later the disease showed up in the two sections infected by eggspores and here too the disease was less obvious in the section accessed by the sun.

A few days later new diseased plantlets appeared regularly in the shadowed sections of the bed whereas, in contrast, the disease had not spread further in the sunlit sections. In the end all shadowed plantlets died and [plantlets] survived only in the sections exposed to the direct sunlight.

The experiments described here thus demonstrate that darkness and moisture favour the development of the *Phytophthora*, light and drought counteract it.

3.7. Effect of increase of air and light on the tobacco nursery beds. Control by Bordeaux mixture.

According to the microscopic examination of diseased tobacco plants, the phenomena observed in Deli, and the infection experiments, we may now consider the *Phytophthora Nicotianae* as the cause of the bibit disease in the tobacco.

Having thus acquired the knowledge of this parasite and, as much as possible, of the factors favouring or hampering the development, we may try to extract from this knowledge an indication for experiments in order to control the parasite, if possible.

One of the first questions presenting itself and meriting consideration was if not another tobacco sort could be found with resistance to the attacks of the *Phytophthora*.[37] Apart from the minor chance of success in this direction, the introduction of other tobacco sorts would meet with practical objections so that measures taken to this purpose must be rejected a priori.

By its finesse of leaf, size, shape and innervation the Deli tobacco is a singular variety, on which indeed its great commercial value is based.

No new variety could be introduced without changing something in these characteristics. A lower intensity of the plague with another variety would probably not outweigh the loss in commercial value of the newly cultivated product.

Originally, some were of the opinion that tobacco of a few estates in Deli could withstand the disease and the seed from such estates was much in demand. In the long run it became clear that the nursery beds sown herewith were as susceptible as the others and this measure was given up.

Something different was the question whether it would be possible, by deviating from the routine that had crept in the tobacco cultivation, to produce sturdier plants more resistant to attacks of the *Phytophthora*; this turned out to be possible.

Routine had become to spray the nursery beds every morning and evening, to lay them out closely together, and to keep them shut off from the sun as much as possible. In chapter VI we saw that the *Phytophthora* could not support drought and that direct sunlight killed the germs almost instantly.

Thus it was tested if, possibly, with less spraying and higher shelters, by admitting more air, the tobacco seedlings would not be harmed.

The opposite, however, happened to be the case, the bibit became shorter and stockier, but much sturdier and not so lush as before.

An experiment was done with a few nursery beds laid out on completely identical soil and with the same orientation relative to the position of the sun. From one bed the cover was taken away early in the morning, a few days after the germination of the seed. Toward nine o'clock, when the sun became burning, the bed was covered again, and then kept open each day during a longer lapse of time.

A few days later already a difference in development became visible, the plantlets directly sunlit leaving the others far behind in strong growth.

The same experiment was performed with potted plants, with the same result, again it was shown that plantlets only four days old could support the full sunshine without harm.

Furthermore, experiments at Buitenzorg demonstrated that spraying once in two days was more than adequate, yes even refraining from spraying during three days had no deleterious effects. Of course moistening by rain was excluded in these experiments, finally it became clear that the beds needed to be watered only when the soil had dried to some depth.

In addition, the repeated drying of the surface of the nursery bed prevents the growth of a thin layer of algae etc. on the bed, something encountered frequently on beds laid out in the old way, on impermeable soil. It goes without saying that disease germs readily continue developing is such a moist layer.

When we combine these results with the experiments described in the preceding chapter we may represent the influence of increasing light and air on the development of the *Phytophthora Nicotianae* and of the tobacco plantlets as follows:

	light	darkness	moisture	drought
Phytophthtora	-	+	+	-
tobacco plantlets	+	-	-	+

These results, obtained in preliminary experiments at Buitenzorg, laid the foundation for the experiments at a larger scale in Deli, described in the next chapter. Beforehand a few words on the control by means of Bordeaux mixture.[38]

The experience gained with the control by Bordeaux mixture of similar diseases as the bibit disease in other crops suggested that a spray with this mixture might yield good results here too.

But before applying in this matter measures to control *Phytophthora Nicotianae* at a large scale experiments were needed to check whether the mixture could possible cause damage when applied to young tobacco plantlets.

Therefore it was first checked whether the spraying with Bordeaux mixture also had an effect on the germination of the seed. Two pots were sown and one was well moistened with Bordeaux mixture; in both pots the first germlings appeared after the same number of days whereas no difference could be seen in the number of plantlets that with any justification could be attributed to the effect of Bordeaux mixture.

The same result was obtained after having seed germinated of moist filter paper drenched in freshly prepared Bordeaux mixture. Here again the mixture had no effect on the development of the plantlets.

Thus it was clear that a treatment before germination caused no harm, the same result was obtained when seedlings four days old were treated with Bordeaux mixture.

When such young and still weak plantlets can support a spray with the mixture it will be no wonder that further experiments demonstrated the harmlessness to larger plants too.

Resuming the main points communicated in the preceding pages we found:

- that increasing, in appropriate measure, light and air (coupled with drought) favour the growth of the tobacco bibit;
- that a spray with Bordeaux mixture has no effect on the germination capacity of tobacco seed and on young seedlings, nor on larger tobacco.

3.8. Field experiments in Deli

We arrive now at the description of the experiments which were performed at a large scale in Deli whereto the results obtained in Buitenzorg served as a guide. Often we will lapse in literal repetition of what has been communicated earlier [a] about these experiments. From some experimental fields we later received more detailed figures, which caused some minor changes, as will appear from the comparison of the following data and the results mentioned earlier.

Considering the culture in Deli, we already indicated that the bibit disease occurs on the most diverse soil types and at very different altitudes above sea level.

In these experiments it would be possible that the bibit on these different soils would behave differently with the earlier of later exposure to direct sunlight. Similarly, it would be possible that the proximity of sites, where e.g. during the preceding year the bibit disease had reigned heavily, affected the occurrence of the disease in the experimental fields.

Therefore, in choosing the experimental fields, as much attention to the circumstances was paid as possible and [it was] tried, through a large number of experimental fields (over 400), to obtain a result as pure as possible.[39]

The lay-out of the experiments will be made clear by the following instructions for the experimental fields.

On a regular flat terrain of only a single soil type, situated near to good irrigation water, and where good and easy supervision is assured, 50 numbered nursery beds [will be] laid out, numbered and arranged as below

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
31.	32.	33.	34.	35.	36.	37.	38.	39.	40.
41.	42.	43.	44.	45.	46.	47.	48.	49.	50.

Where possible the beds are situated on five rows of ten beds each. The mutual distance between the beds is at least six feet.[40]

The realization of the beds is done according to the practice of the estate where the experiment is performed.

a Report on the experiments to control the bibit disease in the tobacco *(Rapport over de proefnemingen ter bestrijding der bibitziekte in de Tabak).*

The covers are made so that they exclude the rain (irrespective whether made of lalang or atap). The direct sunlight should be excluded as much as possible, thus the slope of the shelters should be made toward the side of the sun.

Sowing be done as usual, the seed mixed with ash or sand. Watering of the beds be as usual. When the shelters of the beds are taken away watering be done only in the morning, during continuous drought also in the evening.

On these experimental fields we proposed to study the effect of light etc. on the vigour of the tobacco bibit, also in relation to the occurrence of the bibit disease.

Therefore a certain number of these nursery beds (group I, see table page 73) remained permanently covered, i.e until the age at which the shelter is taken away customarily, before proceeding to transplantation.

From other beds (group II) the shelters are taken away three days after the germination of the seed at 6 o'clock in the morning, at 9 o'clock they were put in place again, and so every day until and including the fifth day after germination. Then the shelters were replaced on the beds only at 10 o'clock, on the seventh day at 11 o'clock, the ninth day at 1 o'clock and the twelfth day after germination they were left open permanently.

Another group of beds (group III) is opened at six o'clock in the morning 5 days after the germination of the seed, closed again at nine and so on until the 7^{th} day, when they are closed only at 11 o'clock. On the twelfth day these beds were left completely open.

With the beds of group IV the shelter is taken away at six in the morning seven days after germination, replaced at nine, and so on until the ninth day when the beds are covered again at 11 o'clock. On the 11^{th} day the beds are no longer covered.

In view of the large number of beds that would be needed for the Bordeaux mixture and the control, which then would become difficult, the effect of Bordeaux mixture was studied on these same fifty beds. To this purpose the same beds were classified in such a way that the beds under category A were treated with Bordeaux mixture 3 days after *sowing*, and further at every seventh day.

The beds of category B were treated with Bordeaux mixture 2 days after the *germination*, and furthermore after every seven days. Category C indicates the beds treated with Bordeaux mixture 4 days after germination, and then every seventh day, whereas in category D those beds are placed that are *not* treated with Bordeaux mixture.

For the application of the treatment with Bordeaux mixture this has to be, as much as possible, freshly prepared each time from good copper sulphate and quicklime in the proportion of 2 parts copper sulphate and 2 parts lime on 100 parts water.

The spraying was done by means of well working pulverisers, in the morning after the rising of the morning dew.[41]

Of course no watering was allowed before and after treatment and similarly in the evening, except during great drought. About 1 litre of Bordeaux mixture was used per bed of 18 square feet.[42]

The design of these combined experiments will be clear when we check the classification of the beds below. The beds lay according to the scheme given above, numbered as indicated there, and categorized as follows:

	Category	**A**	**B**	**C**	**D**
Group		**Beds treated 3 days after *sowing*, etc.**	**Beds treated 2 days after *germination*.**	**Beds treated 4 days after *germination*.**	**Beds *not* treated.**
I	Beds permanently under shelter.	1.34.48.	12.32.38.	10.35.40	4.7.15.18. 23. 26.29. 31.37. 42.45.
II	Beds opened 3 days after germination.	2.46.	5.30.	21.49.	8.24.27.43.
III	Beds opened 5 days after germination.	14.36.	9.33.	3.20.	6.11.17.39.
IV	Beds opened 7 days after germination.	22.47.	16.41.	25.44.	13.19.28.50.

From this one sees that the beds for the various treatments have been arranged as regularly as possible. The 11 beds from group I category D are purely control beds. In total 23 untreated beds are opposed to 27 beds treated with Bordeaux mixture. Whereas the shelters are taken away in the usual manner from 20 beds, 30 beds are handled in a different way.

For these experimental fields notes were made of:

1° rainfall,

2° weather conditions (state of the air, atmosphere etc.),

3° time of seed germination,

4° when beds are open, at which hours,

5° when beds are sprayed with Bordeaux mixture,

6° appearance and spread of the bibit disease,

7° general comments about the state of the bibit, etc. etc.

In order to obtain a better overview of the results we will separately discuss the data of the experiments on the opening of the beds and on the treatment with Bordeaux mixture.

It was noted that in Europe a treatment with copper salts resulted in a stronger development of the foliage, with potato plants and also with the grapevine. The effect on the young tobacco leaves is, however, not so that much change can be noticed in the appearance of the plants; where this was marked it is reported separately.

Experimental field No 1. Soil consisted of rather sandy grey clay, poor in humus. Drainage was rather faulty, the height of the beds was well over ½ foot.

The beds were laid out East-West, without side protection. At the edge of the bed some sunshine could enter, but without having an effect on the development of the bibit.

On the control beds the plantlets stood nicely equal over the whole surface of a bed.

In 1893 the bibit disease had appeared in a nearby section, to a limited degree. This year the disease had manifested itself in the proximity of the experimental fields.

The diseased beds, however, had been destroyed before the sowing of the experiments and the others treated with Bordeaux mixture, whereupon the disease did not spread further.

All beds germinated at the same time, 6 days after sowing (30 March). Fourteen days later no difference in size could be seen and the stand of all plantlets was quite regular.

The beds II had been opened permanently on the preceding day and had received rain in the morning of April 10^{th} 4.8 mm, April 12^{th} 1.3 mm. This is a very small amount which had no effect, they were loose showers immediately followed by clear, drying weather.

The beds IV had been open only until 9 o'clock.

The fact, that these beds of group II and IV were quite regular leads to the conclusion that the additional sun from 9 to 1 o'clock not yet had an effect. If one placed himself at one side of the experimental field, the bluish green tint scattered over the opened beds, also those that had been opened but covered again in the afternoon, was striking. They did not show the clear light-green colour of the permanently covered beds; but this was the only difference. As mentioned above rainfall was quite sparse; the weather was very dry and warm.

Due to the fierce sun some of the oldest leaflets (under-leaf) on the opened beds, mainly in group II, were yellow, with here and there a dried edge where they rested on the soil.

On 17 April a rain shower of 47 mm caused much damage, mainly because of the strong wind by which it was accompanied. The next day, the traces of the rain could be seen on the leaflets, cracked and torn to pieces. Near the crack some water had mostly penetrated the leaf in the intercellular spaces and, as the air had been driven away in those places, the vicinity of such a crack stood out dark green against the other tissue.

On 21 April the plantlets of the opened beds in general clearly lagged behind the others, though here and there, where on the opened beds the plantlets were more crowded, there are some bibits that in size give in nothing to the finest bibit of the covered beds.

Now follow seven days with nearly continuous rain, among which a shower of 50 mm, but without heavy wind; the opened beds showed to suffer no more damage from the heavy rain, but the plantlets remain compact of stature and slightly more yellowish.

After 34 days already some beds had bibit ready to transplant, and we find taken down that *fine* stood 7 beds of group I, 2 beds of group III, and 3 beds of group IV, whereas yellow and *retarded* were 1 bed of group II, 3 beds of group III and 3 beds of group IV. Thus of group II the fewest [were retarded], though these had been open longest and just in the beginning had endured severe drought.

The result thus was

covered beds	35 % *fine,*	65 % *good*,	0 % *retarded*,
opened beds	17 % ” ,	59 % ” ,	24 % ” .

The experiment was continued for another few days but due to the heavy occurrence of the disease the stand of the beds could no longer be judged adequately; in essence the proportion remained the same as just recorded.

Percent-wise we find here an unfavourable result with the increase of air and light. This must certainly be attributed in part to the fierce drought of the first days, of which the effect remained visible in the later development.

Did we so far leave the bibit disease completely aside, now we will see whether a relation also exists of this disease with the opening [of the beds]; the beds treated with Bordeaux mixture will here be left out of consideration.

19 April we find the first mention of the occurrence of the disease, 27 April we find the disease already in several beds, that is in 5 beds of group I D, 3 beds of group II D, whereas only one bed of group III D is diseased.

10 May the situation of the beds was as follows (diseased beds had not been destroyed): 8 beds of group I D are diseased (of which heavily diseased 4, 7, 15,18, 29, and 42, sporadically diseased are 26, 45); of group II D two beds are diseased (heavy 8, sporadic 43); of group III D 3 beds are diseased (heavy 6, 17, sporadic 39); of group IV D 2 beds are diseased (heavy 19, sporadic 50.).

Thus the proportion is that out of 11 beds I D 8 are diseased or 73 % whereas of the other 12 beds 7 were diseased or 58 % and so of the

covered beds are diseased	73 % of which heavy	55 % and sporadic	18 %
opened ” ” ”	58 % ” ” ”	33 % ” ”	25 %

Thus, the disease on the covered beds sooner assumed a more severe character, whereas with the opened beds the total number of affected beds was lower. In addition we see that the disease, comparatively, is far more sporadic on the opened beds where it spreads less rapidly. The plantlets on the opened beds seem to be more resistant and vigorous, the effect of drought and light thus made itself felt.

Experimental field No. 2. The soil on which the beds had been laid out consisted here mainly of black lalang soil with a loamy, poorly permeable subsoil. The terrain was slightly sloping. The beds had been laid out in five sets of ten, with the opening toward the south, the sides closed by so-called side-tinkaps. The sun was excluded nearly continuously and in any case had no influence on the condition of the separate beds.

The beds were raised about 1 foot, with deep gutters in between, draining thoroughly.

Per bed of over 100 □ feet 1.06 g of seed was used.[43]

After 6 days the germination of the seed was quite regular, so that three days after the seedlings became visible no difference between the beds could be seen. 14 days later (25 March) a difference in stand could be observed, the beds that were open longest (group II) all looked retarded, except bed Nº 43. The weather during the days the beds II were gradually more and more exposed to the sunlight was not so favourable. 16 March the beds are opened for the first time until 9 o'clock, while 25 March the shelter was taken away for good. During all these days only 9.5 mm rain fell only on 16 March and the weather is recorded as very warm. That the drying power of the sunshine was here of great influence appears i.a. from the good condition of the beds of group III, beds 1 and 36 even fine, whereas group IV, first exposed to the sun on 20 March, did not differ from the beds that had been covered permanently. The beds on the lowest part of the terrain are poorest, but this was also the case with the covered ones, and apparently should be attributed rather to the soil which was tilled only very shortly before seeding, 36 days after the germination (18 April) the beds generally looked fairly healthy and vigorous, the early opened bibit looked more sturdy than the others, and was more stocky in appearance.

Here too the bluish tint lying over the bed was conspicuous. On March 25th the beds of groups II, III and IV were opened permanently; since then rain fell only 9 times, among which one shower (17 April) of 35 mm, whereas the others only brought 4 mm at most. Thus the drought here has not been without effect, the bibit was rather old before being transplantable and on the opened beds short and stocky. An important difference between the stands of the beds could, however, not be observed.

The best of group II, which were retarded at first, became at last equal to the others.

During this great drought nothing like bibit disease could be noticed. After 25 April the weather changed and on 3 May 132 mm rain fell in 8 days, only the 2nd May remaining dry.[44]

The bibit disease showed up on April 26th already.

If we check the spread of the disease, and skip the beds in categories A, B and C, and consider only category D we find 9 beds diseased in group I D and 10 beds in the groups II D, III D and IV D.

So, the proportion diseased of the covered beds is 82 % diseased, and of the opened beds 83 %, which is no difference of importance.

This result should probably be ascribed in part to the continuously moist weather, where the opened beds had no opportunity to dry and thus remained in the same unfavourable situation as the covered ones relative to the disease. Maybe the great drought at the onset has also caused damage and given the plants less resistance to the *Phytophthora*, when the sudden intense humidity caused such a great change in the weather situation.

Experimental field No. 3. Here the experimental plots were laid out on black lalang soil that was fairly rich in humus.

The orientation of the beds was chosen here so that the sun remained excluded as much as possible.

The situation of the terrain did, however, not allow the take the orientation exactly East-West so that the covered beds were also partly sunlit in the morning and afternoon. The beds were closed at the sides by lalang mats. Sowing was on 20 March and a fortnight later nearly all beds had come up well.

On the first two experimental fields the seed needed only six days for germination. The altitude of this experimental field (± 388 m) probably had an effect since it takes long for the seed to germinate, not only on the experimental plots but also in the sections.

As the soil had not been burnt, the beds here and there suffered much from ants which carried the seed away, but these beds could be re-sown in time.[45]

During this fortnight there was little rain though the sky was continuously clouded.

Now, in this experimental field the effect of more sunlight on the plantlets of the opened beds and on those places where the sun could penetrate the covered beds was noticeable.

These plantlets not only were advanced in development relative to the others that had received no sunlight but also stood fresh green and lacked completely the blue-green colour which characterized them on the other experimental fields. A partial explanation of this phenomenon we think to find in the position of the estate, about 388 m above sea level. It seems to lack there, with moist weather and covered sky, the warmth necessary for the rapid development of the bibit. Each increase of sunlight thus benefits the young plantlets, always assuming that the weather is moist with nearly continuously covered sky.

Soon the weather changed, after some ten days with clear weather and drying sunshine a few showers came alternating again with dry days. The covered beds now also have a better stand and look nicer than the more stocky bibit on the opened beds.

Here and there the underleaf of the bibits on the opened beds had yellowed somewhat but in no way so much as on the lower estates. Heavy showers of 24, 62, 50 and 47 mm did not damage the leaflets of the opened beds.

On this experimental field is was striking how the beds, that had been opened early, suffered less from ants and vermin than the others.

Due to the changes in the weather conditions the stand of the beds varied considerably, but we should also take into consideration what has been mentioned above about ants that destroyed some beds.

On May 17th we find transplantable bibit on several beds and we noticed that the stand of the bibit was fine on the following beds, No. 11, 21, 32, 43 and 44. Good were No. 1, 2, 4, 5, 8 , 9, 12, 13, 14,16, 17, 19, 22, 23, 24, 31, 34, 35, 36, 43, 46, 47 and 48. The stand on the other beds was retarded.

If, for the time being, we disregard again the treatment with Bordeaux mixture, we find 5 beds noted as *fine*, of which 1 belongs to group 1 D and 4 to groups II-IV D.

Thus among the *covered* beds 5 % look fine and of
the *opened* “ 13 % “ “ .

Of the 23 beds denoted as *good* 8 belong to group I D, 15 beds to the other groups.
So the proportion is that of the *covered* beds 40 % has a good stand
and of the *opened* “ 50 % “ “ “ “ .

As *retarded* 22 beds were described, 11 belonging to group 1 D and tot the opened also 11, so that the proportions are of the
covered beds 55 % *retarded* against
opened “ 37 %,

Consequently the result of the stands was:

	fine	good	retarded
covered beds	5 %	40 %	55 %
opened “	13 %	50 %	37 %

From these figures we see that, proportionally, the opened beds have a better stand than the covered ones. As we argued already, this certainly must be ascribed largely to the location of the experimental field. Now let us look how it is with the occurrence of the bibit disease, leaving categories A, B and C out of consideration.

We find that in category D nine beds got diseased, all belonging to group I. Therefore 45 % of the covered [beds] became diseased whereas of the opened beds none became diseased. Here then the result of opening the beds is quite noticeable and it appears that the bibit with respect to its disease resistance is strengthened considerably by sunshine, whereas the *Phytophthora* in her occurrence is counteracted. It should be kept in mind that this experiment was performed on a so-called upper-estate.

Experimental field no. 4. For the lay-out of the experimental beds the same design was followed as before.

The orientation of the beds was nearly N. East and S. West with the opening toward the East so that morning and afternoon sun could enter the beds. The beds had no side-tinkaps. Only from about ten-thirty to well over two o’clock the sun remained excluded from the beds. The soil on which the beds were made was a loose, black soil, fertilized with guano by straying it over the field. The last planting was about 8 years ago, the subsoil was loosened 14 days before sowing and the upper soil turned over 1 foot [deep].

The seed germinates on all beds at the same time, in the beginning no difference in stand can be seen between the beds. After a fortnight bed No. 29 stood by far the best, but the other beds of group I D were less good, even less than the opened beds. About 14 days later (10 April) the difference in colour between the opened and closed beds became conspicuous.

The plantlets on the beds without shelter are more equal in size, one does not find on these beds a few plants together that are far more advanced than the others, as is the case on the covered beds. The weather during the last three weeks of this experiment had been exceptionally warm and dry; from 28 March to 10

April there was not a drop of rain. Because of this great drought the upper crust of the soil on the opened beds became very dry and cracked here and there. This was not beneficial to the development of the bibit and, generally speaking, the covered beds were in advance of the others accordingly.

On April 12th the first disease was recorded, the weather began to change slightly, it became wetter, and the number of diseased beds increased continuously. It remained remarkable, however, that on the opened beds the disease did not spread so fast as on the others. All beds (20 April) had suffered more of less from the drought. As an experiment the beds No. 1 – 5, 11 – 15, 21 – 25, 31 – 35, and 41 – 45 were sprayed with guano (the beds were sprayed twice with 8 days interval; the amount of guano applied per bed was about 100 g in 6 litres water).

On May 5th it appeared that the beds thus treated had become greener indeed, but had not grown more; thus on the size of the plantlets it had practically no effect.

Looking again at the stand of the beds, first in general, without considering the treatment with Bordeaux mixture, we find that the beds stood as follows:

fine: 1, 2, 4, 10, 20, 44, 45, 46.

good: 3 , 7, 8, 17, 14, 13, 11, 21, 24, 25, 26, 27, 28, 29, 39, 38, 37, 35, 34, 41, 47, 48, 49.

retarded: 5, 6, 9, 19, 18, 16, 15, 12, 22, 23, 30, 40, 36, 33, 32, 31, 42, 43, 50.

So we find that of the 8 *fine* beds 4 belong to group I and 4 to the other groups.

23 beds are found to be *good*, of which 8 belong to group I and 15 to the groups II, III and IV, whereas *retarded* are 8 beds of group I and 11 beds of the other groups. So we have the following proportions:

	fine	good	retarded
covered beds	20 %	40 %	40 %
opened beds	13 %	50 %	37 %

From these figures it might be concluded that the finest bibit grew on the closed beds, which might be explained with a view on the drought. This made its effect felt also on the covered beds, where in this experiment the sun could enter too. Where the plantlets stood close together, as on the fine beds, the soil between the plantlets remained moist and the bibit could continue to grow. The same was, of course, true for the opened beds though to a less degree. The good and retarded beds differ slightly in number. This experiment might lead to the conclusion that the opening has had little effect; one should, however, keep in mind that the orientation of the beds had to be chosen so that the closed beds were also sunlit during a large part of the day. It would have been more amazing if there had been a noticeable difference.

If we check the proportion of the beds with respect to the bibit disease, leaving the beds of categories A, B and C out of consideration, 4 of the 11 beds in group 1 D are heavily diseased, whereas in group II D, III D and IV D 6 out of 12 beds are heavily diseased and 2 sporadically, so that

of the *covered* beds 36 % is diseased against
of the *opened* “ 67 %.

Here the disease occurs less in the covered beds than in the others, which has thus to be ascribed here to the sheltering. During the last showers these kept the rain out of the beds when the disease appeared, whereas they were no longer watered. Consequently these beds remained dry, the rain kept the others, that had not been covered, continuously moist.

Experimental field No. 5.[46] In the usual way 50 beds were laid out on light sandy soil, in an East-West orientation, so that the sun could not enter, which was also excluded at the sides by means of shelters.

After seven days all beds had germinated equally; 7 days later no difference could be seen, 15 days later (March 29th) the difference between covered and opened beds begins to become noticeable. The plantlets, that gradually had become used to the sun, had not such tender leaf and were more blue-green, the whole plantlet made a more robust impression. The weather during the last 10 days had been quite warm, the only rain shower of 7 mm fell on March 26th. The foliage of the opened beds here too had the blue-green tint that was already indicated elsewhere.

Due to the serious drought, accompanied by rather strong wind, the opened beds suffered much; they were clearly retarded relative to the beds that still were covered and where the sun thus had little effect. In the end the long-lasting drought (April 19th) made itself also felt in the covered beds (in general watering was done as little as possible), so that the differences, visible before between the beds with different treatments, began to become less conspicuous.

As mentioned before the opened beds had a blue-green appearance, later they coloured very yellow during some days, the drought became too severe. When however they got over this period they recovered gradually and after all turned nicely green.

The drought was really serious as shown by the fact that, when the covered beds were opened a few days before transplanting, leaflets which touched each other or rested on the soil and against which moisture (from watering) had collected were burnt by the strong sun. Brown, irregular flecks appeared at the edges of the leaf.

In view of this drought plants were watered in the morning as well as in the evening with on average 40 litres per three beds of 18 feet, the sparse rain days excepted.

The supervising assistant tagged the following comment onto the report on the experiment: 'The bibit of the *early opened beds* turned, in general, conspicuously yellow shortly after opening, but then recovered in the course of some ten days, in part considerably and later looked sturdy and intensely dark. In nearly all these beds, however, there locally remained yellow spots that did not produce plantable bibit.

The *covered beds* had been opened some 5 days before the supposed plantability and then looked so good that one might have thought to obtain at least a 1000 plantable bibits per bed.

However, after the removal of the shelters this bibit also turned very yellow and did not recover any more, notwithstanding later rainfall, probably because the bibit then was already too old (i.e. 45 days).'

For the experimental beds of this estate it could be worked out, thanks to the dedication of the assistant, when and roughly how much bibit per bed was transplantable.

The time at which the plantlets could be pulled up differed only little between the various beds, at most four days. The average number of plantable bibits per bed (12 beds were not plantable) was 400. Assuming that the beds which produced less than 300 bibits were retarded, those from 300 to 600 were good, and those over 600 could be considered fine, we find:

that *fine* are the beds No. 1, 2, 4, 6, 16, 34, 36.
that *good* " " " " 3, 7, 8, 10, 12, 20, 21, 26, 31, 37, 38, 39, 40, 42, 43, 44, 46, 47 and 48.
retarded " " " " 5, 11, 15, 17, 19, 27, 29, 30, 34, 35, and 49.

Whereas as *unplantable* are specified, either because the bibit was too yellow and retarded or too small, the beds No. 13, 14, 18, 22, 23, 24, 25, 28, 32, 33, 45 and 50.

Working out the proportion of opened and covered beds we see that:

	fine	good	retarded	unplantable
of the *covered* beds	10 %	50 %	20 %	20 % are and
of the *opened* "	16 %	33 %	24 %	27 %

These data do not allow many conclusions, only the following, that we see here also that the covered beds endured the drought slightly better; 60 % produced plantable bibit against 49 % of the opened beds, whereas among the opened beds about 11 % more beds produced *retarded* and *unplantable* bibit.

Though these beds recovered somewhat, they did not seem to have received sufficient moisture to let disappear all effects of the drought.

As no bibit disease occurred in these experimental beds, we cannot determine the resistance of these experimental plots against the *Phytophthora*.

Experimental field No. 6. Here the beds could not be laid out in the usual manner with 5 sets of 10, but were laid out in 10 sets of 5 beds each. The beds were open to the South, without sidelong protection.

The red sandy soil on which the beds were placed showed to be quite infertile so that a layer of about one half foot with good black soil was placed on the beds. All beds germinated simultaneously and the first few days after germination [they] looked rather good.

Soon this changed due the highly unfavourable weather that caused partial failure of this experiment. The beds germinated on April 16th, the next four days it rained rather heavily, whereas on April 21st the sky remained cloudy all day and the soil thus did not dry up.

The beds that were opened 3 days after the germination thus met with very bad weather. The beds first opened 5 days after the germination also met with highly unfavourable weather, since these were opened first on the 21st, the two following days the weather was clear, but then followed again 4 moist days of which the first brought a.o. 66 mm rain.

These beds however had been covered during the first showers so that they stood better than the beds just mentioned. Of group II we find on 5 May 9 out of the 10 beds already with a poor stand, if for the time being we set apart those [beds] that were treated with Bordeaux mixture, we find that all beds of II D are poor, whereas of III D two are good and 2 bad. Of the last group IV D all beds had a bad stand, what can be explained if we only take the weather into account. These beds had been opened on 23 April whereas 24-27 April brought continuous rain.

Comparing the condition of the beds I D, which remained permanently covered, among themselves we find that of the 11 beds 4 are fine, 6 good and 1 bad.

On May 7th the condition of the beds was recorded as follows:

	fine	good	retarded
of the *covered* were	36 %	52 %	12 %
opened "	3 %	25 %	72 %

When recording the condition of these beds it was tried to disregard as far as possible the damage done by the bibit disease, which on the opened beds caused much destruction due to the rainy weather. This follows i.a. from our notes on I D, 1 bed severely and 10 sporadically diseased, whereas the remaining beds of category D (II, III and IV) were all severely diseased.

Consequently we find in category D that of:

the *covered* beds 91 % is sporadically and 9 % severely diseased.
the *opened* beds 0 % " " " 100 % " "

Where we concluded from the earlier experiments that opening of the beds can be useful, here we see just the inverse and it becomes clear that with continuously bad weather permanent cover is profitable.

That it was not only the rain which caused damage, but the associated bibit disease, is shown by the fact that otherwise all bibit would be gone or torn to pieces, whereas this was certainly not the case on the opened beds. Some other facts, touched upon later under the discussion of the Bordeaux mixture, also point to the same [conclusion].

Considering the results of the experimental plots with respect to experiment I the following figures are obtained.[47]

These results do not show much regularity but if this had been the case it would have been more amazing then now. The main purpose of this experiment was to allow greater access to air so that the humidity condition can be better regulated. In most cases we have not been able to succeed, either by excessive drought or by excessive humidity. In general the weather was more than unfavourable to these experiments.[48]

In addition we should not overlook the necessity to determine in advance that the shelter should be opened on that and that date, from so late to so late, because it was not practicable to judge oneself each morning, for every experimental field, how to operate.

To counter this objection as far as possible the persons, who had the daily supervision of the experiments, took notes of the weather condition as accurately as possible.

Experimental field No.	Group	Categories A B C D %			Category D %			
		fine	good	retarded	diseased	severe	sporadic	healthy
1	I	35	65	0	73	55	18	27
	II - IV	17	59	24	58	33	25	42
2	I				82			18
	II - IV				83			17
3	I	5	40	55	82			18
	II - IV	13	50	37	0			100
4	I	20	40	40	36	36	0	64
	II - IV	13	50	37	67	50	17	33
5	I	10	50	40	0			100
	II – IV	16	33	51	0			100
6	I	36	52	12	100	9	91	0
	II - IV	3	25	72	100	100	0	0

Considering each experimental field separately we saw how much influence just this factor has in explaining the results. These have been described for each experiment separately, as a general result the following seems to be valid:

very early opening damages the bibit during great drought and great humidity; with average weather is has about the same effect as when the orientation of the beds is such that the sun shines on the plantlets until ten thirty in the morning and after three in the afternoon;

with increasing light and air the bibit becomes more stocky, the leaflets are more solid and in general less susceptible to bibit disease;[49]

if bibit be grown on beds with detachable covers this detaching should be done only when the weather is duly considered and thus adequate and continuous supervision is possible;[50]

when the production of the bibit beds must be left to the field coolies it is, under normal Deli weather, possible to obtain the same results by choosing the orientation of the beds so that the morning and afternoon sun can nicely enter the beds.

On the same experimental fields the effect of a treatment with Bordeaux mixture was studied, in the way described earlier. Every time this was, as far as possible, freshly prepared and sprayed over the beds by means of pulverisers, using about ½ litre of the mixture per bed of 3 by 18 feet.[51]

With the exception of one estate the bibit disease always appeared when the beds of the categories A, B and C had already been treated repeatedly. Differences in the occurrence of the Phytophthora or [of] the spread of the parasite could not be observed among these categories.

To simplify the survey we will in the following take the categories A, B and C together to oppose them to category D.

In order to influence the figures, to be produced by this experiment, as little as possible in a favourable sense, the plantlets affected by the bibit disease were not immediately removed and burnt, but left standing until after the end of the experiment. In this way a very favourable opportunity existed continuously for the other beds to become diseased too.

If we think here of the lessons practice taught us about the spread of the infection, it will be clear that the figures obtained are too much in unfavourable sense rather than the obverse.

According to the scheme one sees that treated and untreated beds were mixed so that also in this respect it was attempted to perform the experiment as purely as possible. When the disease appeared in a bed without yet being severe then in the first days such a bed was cleaned from worms in the morning after all healthy beds had been dealt with. When after all the disease became rather severe in such a bed, the worm picking was halted and the bed was only watered when deemed necessary. When Bordeaux mixture had been applied before then the application was continued. Care was taken only to avoid all immediate contact with the diseased plants as far as possible.

Experiment No. 1. For weather conditions, soil and design of the experiment we may refer to the first experiment. Some beds, earlier infected, improved again and did not show any sign of disease when the experiment was ended.

These beds were No. 24, 25, 47 and 49, one untreated and the other three treated with Bordeaux mixture. These beds were incorporated in the end result.

After the heavy rains the disease did not spread any further on the treated beds, but [spread] strongly in the untreated ones.

The result of this experiment was that 25 beds in total were diseased so that
of the *untreated* beds 73 % was diseased and
of the *treated* " 30 %.

Experiment No. 2. The disease appeared first on 23 April, on beds sown 7 March.

On April 23rd the [following] beds were diseased: No. 4, 6, 11, 13, 23, 24, 26, 29, 31, 37, 42, 43 and 45, all of them untreated beds, among which 8 remained covered and 5 were opened.

On May 2nd had also become diseased: No. 15, 17, 19, 27, 28, 32 and 39, of which 2 were covered against 5 opened.

On bed No. 32, the only one that became diseased notwithstanding treatment, only two plantlets were attacked (the position amidst diseased beds was very unfavourable).

Hence the proportion is that 1 became diseased out of 23 untreated or
of the *untreated* beds 82 % became diseased, against
of the *treated* " 4 %.

Experiment No. 3. We already pointed out what effects the opening of the shelters had, so that disease only occurred in beds that remained closed, that is in group I.

Of the treated beds No. 34, 35 and 40 became diseased.

On bed No. 40, a fortnight after the disease had been recorded, no trace thereof could be seen.

Of the untreated beds were diseased No. 4, 15, 18, 26, 29, 37, 31, 42 and 45.

With certainty the disease appeared first in the beds No. 15, 26, 29,37 and 45, only later she was found in the other beds.

Hence the proportion, all beds taken together, is that became diseased
of the *untreated* beds 39 %
" " *treated* " 11 %.

If we consider only the beds of group I, where the drying up due to opening of the beds remained without effect, 89 % of the untreated beds became diseased versus 33 % of the treated [ones].

As we wrote earlier the weather during this experiment was generally moist.

Experiment No. 4. The beds were laid out on 11 March, the bibit disease showed up first on April 12th, but to a very low degree, till April 20th the disease had remained almost stationary. Now came some rain days and the disease spread more. The first days of May the bibit was plantable, at the time 16 beds in total were diseased, of which were noted as *severely* diseased: No. 7, 8, 18, 17, 11, 26, 27, 28, 29 and 50. As *sporadically* diseased: No. 3, 9, 13, 38, 41 and 43.

Hence the proportion of diseased beds was:

Of the *untreated* beds 52 % was diseased of which *severely* 43 % and *sporadically* 9 %.

Of the *treated* beds 15 % was diseased of which *severely* 0 % and *sporadically* 15 %.

During a few days the weather was very unfavourable, the disease then spread rather strongly over the untreated beds, but only sporadically over those threated with Bordeaux mixture.

Experiment No. 6.[52] In the discussion of the first experiment we already indicated the curious conditions prevalent during this experiment. The consequences of the unfavourable weather we find rendered in the results of this experiment.

On May 5th we find 42 beds to be recorded as diseased, out of which were *severely* diseased: No. 5, 6, 8, 9, 13, 14, 16, 17, 19, 20, 23, 24, 25, 27, 28, 30, 33, 36, 39, 43, 44, 47, 49 and 50, *sporadically* diseased were No. 2, 3, 4, 7, 11, 12, 15, 18, 21, 22, 26, 29, 31, 37, 42, 45, 46 and 48.

In this experiment the beds No. 38 and 41 were ignored since they had not emerged.

Of the 23 untreated beds 23 beds are diseased or 100 % and hereof 12 or 52 % severely and 48 % sporadically. Thus the proportions are nearly equal; if we check which beds are severely diseased we see that, with one exception (bed No. 23), they all belong to the opened [ones], whereas all covered beds except one were sporadically diseased.

Earlier already we indicated that this must certainly be attributed to the heavy rains, stopped by no shelter, that kept the soil of the opened beds continuously moist.

Of the 25 treated beds (38 and 41 disregarded) 19 [beds] or 76 % are diseased, of which severely disease 44 % and sporadically 32 %. The uninfected beds all belong to the permanently covered beds of group I.

Here again the covering made itself felt, which first reduced the humidity but also prevented that the mixture was washed off the leaves immediately. Of group I A B C two beds (No. 12 and 18) became diseased but only sporadically.

Since we discussed the rainfall for this experiment already before, we don't need to repeat this. The result on 5 May was that of the

untreated beds	100 % was diseased,	severely	52 %,	sporadically	48 %.		
treated	“	76 %	“	“	“	44 %	“ 32 %

Was this the condition of the beds on May 5th, after this date the weather changed. This had an effect on the further spread of the bibit disease.

On May 16th none of the treated [ones] among the *covered* [beds] remained diseased but of the untreated ones 2 were sporadically diseased or 18 %. On the *opened* beds 15 of the treated [ones] were diseased or 60 %, of which 44 % severely against 16 % sporadically, among the untreated [beds] 6 were heavily diseased or 49 %. Calculated over all beds we find that on 16 May 67 % of the *untreated* beds was diseased, 49 % severely, 18 % sporadically. Of the *treated* beds 60 % was diseased, 44 % severely, 16 % sporadically.

Clearly some improvement did occur, but it also turns out that the Bordeaux mixture works best when the rain remains excluded and that the effect in combination with moderate sunshine is the most successful.

Experiment No. 7. On meagre, mixed clay soil 50 beds had been laid out in the normal manner. In the immediate neighbourhood of the experimental field the disease occurred continuously to a heavy degree. The bibit disease first appeared about a month after sowing.

In general the beds had emerged nicely.

According to the data communicated to us, the disease was observed in the shape of flecks on the leaves.

On June 1st the beds No. 6, 8, 18, 23, 24, 26, 37 and 45 showed the symptoms of the disease. Among these infected beds 5 belonged to group I and 3 to the other groups of beds, that had not been sprayed. All other beds were healthy. The disease occurred sporadically only and manifested itself by flecks on the leaves.

Here again we find less resistance on the not-opened beds. In the end, the other beds were also infected so that on 10 June were recorded as diseased the beds No. 17, 31, 4, 11, 13, 15, 19, 27, 42 and 43, whereas among the beds treated with Bordeaux mixture were found diseased No. 21, 30, 33, 40, 41 and 48. Hence we find that

of the *untreated* beds 77 % became diseased against
of the *treated* “ 22 % “ “.

Experiment No. 8. The experimental beds were laid out here on a terrain that consisted mainly of white clay which let permeate only little water. This was accommodated as far as possible by deep draining ditches. The orientation of the shelters allowed the morning and afternoon sun to enter. The weather varied normally, only in the first days it was somewhat too moist; nonetheless a green deposit soon appeared on the beds.

These were quite densely sown, the bibit emerged regularly and very densely, less Bordeaux mixture was used than elsewhere, to which maybe the less positive result of this experiment should be attributed, as also to the very dense stand of the plantlets so that the underleaf could not be wetted.

The disease appeared in the form of rotten stem base and always only in one or two spots, never spreading over the whole bed. Anywhere else on the experimental fields the disease occurred by way of leaf flecks.

That just here only rotten stem base occurred is perhaps related to the dense sowing by which the Bordeaux mixture remained partly ineffective. No notes were taken here on the disease remaining more sporadic on one bed or the other.

On May 24th the beds No. 4, 11, 13, 28, 32 and 42 were diseased, that is 6 beds of which 5 untreated and one treated, hence at that time 22 % of the *untreated* beds was diseased against 4 % of the *treated* beds.

Later this relationship changed somewhat so that on 31 May the beds No. 3, 6, 9, 21, 22, 23, 27, 36, 41 and 50 had become diseased, so that the proportion became that of the

untreated beds 39 % was diseased and of the
treated “ 26 % “ “.

The disease increased proportionally more on the treated [beds]; we already indicated the dense stand of the bibit and the wet clay soil. With the increasing development of the bibit the larger leaf of course covered the soil more and more, hence it remained moister, whereas in addition the Bordeaux mixture was impeded to moisten everything correctly. In relation to these circumstances the unfavourable result of the experiment needs not to amaze us so much.

The various experiments provided us with the result that became diseased of

exp.	No.	1,	17	*untreated*	beds	or	73 %	and	8	*treated*	beds	=	30 %
“	“	2,	19	“	“	“	82 “	“	1	“	“	“	4 “
“	“	3,	9	“	“	“	39 “	“	3	“	“	“	11 “
“	“	4,	12	“	“	“	52 “	“	4	“	“	“	15 “
“	“	6,	23	“	“	“	100 “	“	19	“	“	“	76 “
“	“	7,	18	“	“	“	77 “	“	6	“	“	“	22 “
“	“	8,	9	“	“	“	39 “	“	7	“	“	“	26 “

In experiment No. 5 no bibit disease occurred.

Imagining all experiments laying together, No. 5 excepted, the most unfavourable conditions, as comes out sufficiently from the foregoing description, have exerted their influence. Here and there, however, favourable conditions were not excluded. Furthermore, these 350 beds form a representative sample of Deli's soil and provide, so to say, a representation of the different altitudes of the estates and the various ways in which nursery beds are laid out and kept up.

Certainly the result of the experiment has been influenced not to a small extent by leaving the diseased beds untouched. In some cases it was obvious that a coolie had transferred the infection from one bed to the other before such a diseased bed had been closed, which will not happen in practice.

Of these 350 beds 155 became diseased or over 44 %. Among these 350 beds were 161 *untreated* and out of these 107 diseased or 66 % against
189 *treated* “ “ “ “ 48 “ “ 25 %.

Without making ourselves guilty of exaggeration we have every right to call the result of this experiment with a treatment of Bordeaux mixture very favourable.

No doubt the figures could have spoken more positively if the Bordeaux mixture could have been applied in response to the conditions and people had not been obliged to keep to the schedule, that necessarily had to be designed in advance for these experiments.

The plantlets used in these experiments were transplanted later, when not coming from diseased nursery beds, and here a treatment with Bordeaux mixture showed to have a favourable effect on the development of the plants, rather than the opposite, as sometimes could be heard here and there.

From the result of this large scale experiment we can conclude that it is practicable, by *applying a Bordeaux mixture of the composition as indicated, in the right way*, to *limit*, if not the appearance then at least the rapid spread of the *Phytophthora*, and *to keep the spread of the bibit disease within rather narrow bounds*.

3.9. Judgement of practicians on the modified treatment of the nursery beds

Part of these results was already presented in 1893 and 1894 in preliminary reports and presentations to the Messrs planters. In order to obtain an answer from practice itself [to the question] in how far the proposed measures had been useful and had answered their purpose, the following questions were addressed to the Messrs managers of the tobacco estates at the end of the planting season 1894.[53]

1°. How are the nursery beds laid out in your estate? (in the section for each field separately, or several together outside the plantation proper).

2°. Did your estate lay out reserve-nursery beds? (on sites distant from the sections).

3°. Have differences been noted in the occurrence or spread of the bibit disease between the nursery beds in the plantation and the reserve-nursery beds?

4°. If so, to what do you think these differences should be attributed?

5°. Have all nursery beds on your estate been laid out in the same way or have experiments been done by changing orientation or cover?

6°. Has it been seen that the changed lay-out of the nursery beds had an effect:

1°. on vigour and development of the bibit?

2°. on the occurrence of the bibit disease?

7°. Have these experiments (question N°. 5 and 6) been performed under approximately equal weather conditions?

8°. Did the bibit disease turn up on your estate?

1°. here and there only sporadically?

2°. or spreading over a larger number of beds?

9°. Did your estate apply a treatment with Bordeaux mixture by means of a pulveriser?

10°. When was the Bordeaux mixture applied?

1°. before the appearance of the disease?

2°. or when the disease had already shown up?

11°. How often was Bordeaux mixture applied?

12°. What was the approximate age of the bibit when treated?

13°. Did you see favourable results?

14°. Did the disease still spread on the same place after treatment or did this occur only after the lapse of a few days?

Most Messrs managers had been so kind to return this [enquiry] answered in detail, sometimes accompanied by valuable comments.

The answers to the first question showed that 13 estates had switched to keeping the bibit beds outside the later plantation. In nearly all cases the care of the bibit had still been assigned to the field coolies.

For this bibit planting outside the fields parts were mostly selected that excelled by either a good soil or the easy proximity of spray water. For the time being, no estates had taken the care of the later planting material away from the field coolie. (This happened indeed in the next year here and there with most success).

With four exceptions (mainly estates that so far did not experience inconvenience due to bibit disease), these 13 estates, that carefully selected the soil for the nursery beds, did lay out reserve beds, sometimes in a large number on multiple sites. An indication indeed that a better choice of soil alone would not safeguard against the disease. On the other estates, which assigned the care of the bibit to the field coolie in his own field, nearly always a reserve was laid out. So, the answer to question 2 was in most cases in the affirmative.

We may conveniently combine the answers to this second question with the two following, which also referred to the reserve beds. The answers indicated that on 20 estates no reserve beds had been laid out. On 22 other estates, where reserve beds had indeed been laid out, no difference was observed in the degree of occurrence of bibit disease between the reserve and the plantation beds.

On two estates people showed to be less satisfied with the reserve beds, in the first case the bibit disease spread faster on the reserve beds that had been laid out close together, in great number and with the same age.[54] This was one of the objections against laying out many beds close together. Then, usually only a small piece of ground was available on which as many beds were placed as possible. These then are close together and once the disease appears it infects the other beds rapidly, mainly by way of the coolies that must walk up and down between the beds.

Thus it is advisable, with the reserve beds especially, to place them far apart, besides the advantages of a treatment with Bordeaux mixture, which reduces the risk of spread of the *Phytophthora* to the utmost. In the other case, where a less positive result was obtained with the reserve, the manager attributed this, besides the reasons mentioned above, also to the lesser dedication of the auxiliary workers (kongsiekans) who took care of the reserve, and who in the nature of things care less about the prevention or control of the disease than the field coolies proper who always run the risk to be later without bibit to plant their fields.

On the other estates a difference was seen in favour of the reserve beds, in as far as these were less affected by the bibit disease. In all these estates the reserve was placed at great distance, sometimes up to 3 km, away from the plantation. With care the sites were selected for the lay-out; black soil was preferred.

Checking the answers to question 4 we find sometimes indicated that the soil, where the field beds had been laid out, was less suitable, at other times that it consisted of hard clay or rocky subsoil difficult to drain, or a soil still wet from a recent flooding.

At other times we find indicated that in a section where the coolies made their beds in the field, some ridges (pematans) were reserved for standby plants. These remained free from disease whereas the disease appeared soon on the low-lying fields of the coolies. By some [coolies] it was attempted, as far as possible, to keep the reserve isolated from the plantation and also to keep the workers separate. The importance of this became evident i.a. from the lay-out of the reserve on one estate, that otherwise was rather heavily affected by bibit disease.

There, the reserve was separated from the other planting by a broad water and was taken care of by separate coolies, but all the same the bibit disease appeared in 5 beds but it was brought in from the outside as could be demonstrated with certainty.

On another estate high, good soil was selected for the reserve beds and these also remained free from the plague, one bed excepted that, situated in a low near the well, suffered much from moisture. Another manager stated that with him the disease occurred in the nursery beds of the coolies and sporadically on one place in the reserve, whereas two other reserve sections were spared. The disease-free reserve bibits were checked with exceptional care, the location was very favourable, completely free, protected from the wind, at a sunny site.

Regularly the covers were taken away on each day without rain. The conclusion will be permitted that the more favourable result here should be attributed largely to the greater care spent on the reserve beds.

Apart from the few cases, just touched upon, where the disease appeared sporadically in the reserve, these beds remained spared, something that may be attributed with certainty to the facts just communicated. As a matter of course the question arises why this better care was withheld from the other bibit? or why the so-called reserve fields were not considered to be the factual nurseries of bibit?

Let us now address the following questions No. 5, 6 and 7; these all refer to the arrangement of the nursery beds.

The usual way to lay out the beds we already described before, how the orientation of the beds is taken E.-W. as usual and the beds at the East and West side are closed off by side-pieces. Moreover, the beds are mostly laid out close together, in one line in N.-S. direction, all this with the objective to keep the direct sunlight out of the beds as much as possible.

We already pointed at the desirability to change the nursery beds so that indeed more light and air can enter, an opinion that later could be defended on firmer ground thanks to the experiments recorded earlier.

This year experiments were performed on 49 estates at bigger or smaller scale changing the orientation of the beds. With 6 estates the result was that under identical weather conditions no difference could be observed between beds laid out E.-W. and N.-S., both types provided plantable bibit of the same quality.

On 14 estates a less favourable result was obtained with the altered direction.

Ascertaining for each case what should be considered the cause of this failure, would be leading us too far off the subject. So it is specified in some cases that [the cause is] the repeated entry of sunlight, while the weather was always dry.

Excess harms, and too much sunshine may harm too, possibly this was also the case here. Furthermore, a general complaint was that the bibit grew so much slower on the N.-S. beds, sometimes with a delay of 5 to 6 days, and this was considered a disadvantage, while others just expressed themselves quite favourably about this remaining smaller of the bibit. The plantlets get another tint (a point to which we already drew attention in the experimental fields) and are more stocky, on the other hand much more vigorous and better able to support drought; also there is a complaint that the seed emerges so much slower and uneven on the N.-S. beds.

The surface of the N.-S. beds dries up rather rapidly after each watering due to the incoming sun, now the seed needs moisture and rather much moisture to germinate and must find this in its immediate surroundings; therefore it is desirable to keep the N.-S. beds well moistened continuously during the first 5 or 6 days after sowing, in fact the sun could then be closed off completely; it will be seen that the seed emerges nicely.[55]

Once the plantlet has well rooted and thus is able to take up moisture from the soil, it will no longer be harmed when the upper layer of the soil dries somewhat. To reject the N.-S. direction for this reason is probably less justified. Not surprisingly there are complaints about dry weather, coupled with poor results of the N.-S. beds. As dry weather during the bibit growing is not usual for Deli, the lay-out of the beds should not be rejected without considering these abnormal conditions. Notwithstanding the great drought the N.-S. beds had been watered as little as the E.-W. beds whereas they should have been watered more than the E.-W. beds which dry up less rapidly.

On some of the other estates (some thirty, of which a few had applied the N.-S. direction to all beds for years already, a proof indeed that this way of lay-out had given good results there) the bibit was grown for one half on E.-W. beds and the other half on N.-S. beds, and as regards the latter a favourable difference in the occurrence of the bibit disease could be seen. Others had a few beds oriented N.-S. by way of experiment and in the end completely changed to this way of lay-out, an indication indeed that here too this change profited the bibit. But the comment was that with the current drought the bibit could be transplanted somewhat later, on the other hand the plantlets were stronger and took on better than the long-stalked, light-green bibit of the E.-W. beds.[56]

That the slow growth of the N.-S. bibit depends strongly on the weather conditions came out clearly i.a. on an estate where bibit from these beds could be transplanted even 6 days earlier, but during very moist weather.

On clay soil the sun did burst the surface of the beds too much during continuous drought; but when the bibit had penetrated deeper into the soil with her root the sun could no longer do harm here.

After rain these beds dried faster, what generally was considered an advantage of this lay-out. On some ten estates, where beds were laid out in a mixture of E.-W. and N.-S. directions, the opinion was for the most part that the latter beds suffered less from the disease, due to more drought in these latter beds.

Thus, taking the results together, we find that against 14 estates with definitely poor result stand 30 with favourable result.

To question 6, on the occurrence of the bibit disease, in four cases only a negative answer was received. The disease occurred only sporadically on 38 estates, on some the disease maintained this sporadic feature during the whole cropping period, on others she later disappeared completely. So we find mentioned i.a. that 'only in the beds laid out first the disease appeared sporadically, when they were still watered regularly in the morning and evening. After reducing the watering no other case occurred.' Mostly, when the disease appeared, even on a small part of the bed only, this was burnt together with the surrounding [plants?], and then no further spread occurred; to what degree the application of Bordeaux mixture contributed hereto, we will see soon.

In this context we find e.g. reported that the disease appeared mid March in 18 adjoining fields with hard subsoil, poorly permeable to water. All these 18 beds were burnt and those nearby were treated with Bordeaux mixture, after which the disease occurred only sporadically.

Among the estates where the disease occurred sporadically 16 considered the N.-S. orientation of the beds to be better in so far mainly, that on these beds no or only very little disease had appeared.

On 20 estates the disease became more serious according to the answers received, so that there the plague could no longer be called sporadic. Some more elaborate answers stated i.a. that much rain fell at the time the disease was severe, whereas later the disease took a calmer course when drought had set in. On another estate nearly all beds became diseased that had been laid out on white impermeable soil, here again the influence of the moist weather made itself felt.

Whereas the disease showed up sporadically on the beds of the field coolies the reserve beds of some estates were affected in larger number; this was already indicated in the discussion of question 3. In one case it was reported that on new soil the disease was more severe than elsewhere. The soil of which these beds had been made had however been tilled quite recently, maybe this had an effect. Finally, on 6 estates the E.-W. beds had been infected only, whereas the others remained safe.

On 5 estates the disease appeared in beds laid out according to both orientations, and on both types with a rather serious character.

Question 9 was about the application of Bordeaux mixture. Let us put aside the results obtained on the other estates and let us look first how the treatment with Bordeaux mixture was satisfactory on the 20 estates where the disease had a more serious character. On four estates out of these 20 no mixture was applied, nor on one estate which thought to have noticed poor results of a treatment in the foregoing year. On three other estates no result was obtained with the Bordeaux mixture; however, one comment needs to be made here, that on one of these three estates the mixture was applied only when the disease had appeared to a severe degree.

From another estate the message was that generally speaking the Bordeaux mixture had been satisfactory, except in two sections where the disease continued to show up. The third estate also applied the mixture only when the disease had appeared and on bibit that was already 20 to 26 days old, sometimes the bibit even had attained an age of 30 to 50 days before being treated.

On three estates where the disease first had a serious character, all beds were sprayed with Bordeaux mixture after its appearance, with the result that the disease became more sporadic. On four other estates only the larger bibit was sprayed after appearance [of the disease]; on one estate the disease continued to spread sporadically, whereas on three others the disease no longer occurred. The same was true for 5 other estates where, however, after the appearance all beds had been treated including those newly laid out.

On two of these estates drought occurred also which probably should be taken into account here.

Let us proceed now to the replies to question 13. The four estates that had not been bothered by the bibit disease did not apply the mixture. Neither was it used on 17 other estates; of the remaining 40 estates it was applied with success on 26, whereas on 13 estates no results were thought to be seen, and from one estate came the answer that the mixture, considered bad for the bibit, was no longer applied. When the answer to question 13 was not clearly in the affirmative, is was taken to be unfavourable, hence the treatment was considered without result on the estates reporting that drought set in at the time of spraying and [that they] thought to have to ascribe the improvement hereto.

Quite certainly this will have had an effect, as we had seen before and argued repeatedly.

If, however, once the disease raged intensely, beginning drought alone was sufficient to let it stop, remains to be doubted, and it is, in view of the results obtained elsewhere, highly probable that the Bordeaux mixture played a role here.

On the other estates where no favourable result was obtained the bibit had been treated only when she was 25 to 35 days old and in some cases only twice, which apparently was not enough.

In one case the Bordeaux mixture was applied by means of watering cans, and the answer to question 13 was negative, but is was added that 'but it is possible that the treatment with normal watering cans is not intensive enough. The disease expanded again with the first heavy rains, the bibit had an age of about 25 days at treatment'. On most of the 26 estates where a favourable result was obtained the disease was stopped completely or nearly so when it had already appeared. With some, where Bordeaux mixture was only partly applied, the favourable results of this treatment were conspicuous, in this vein one estate mentioned that it treated every 5 days, 8 times in total, beginning when the bibit was 14 days old.

An experiment was done with 40 fields, in such a way that between every two treated fields there was always one [field] of which the nursery beds remained untreated. When the rain set in, disease was observed in the fields between the treated ones, whereas the latter had not been attacked. Only after very much rain, and when the treatment had to be stopped by lack of Bordeaux mixture, some of the beds treated previously became infected too.[57]

When the disease did not disappear completely after treatment, it was nevertheless possible to keep her herewith within certain bounds and to prevent that she spread rapidly. On one estate, where last year the bibit disease was serious, the manager now states that he believes to may ascribe to the regular application of Bordeaux mixture that on about 8000 beds 4 or 5 were infected at most, whereas no disease at all occurred in the dry season.

Where we thus see that 26 out of 40 estates applied the remedy with success, whereas 13 others applied it without positive result but in any case without damage, it has to be attributed probably to the method of application when on one estate only the Bordeaux mixture is called harmful to the plants.

Some estates still tried to transplant from diseased beds, treated with Bordeaux mixture, and where the disease did not make progress. In most cases, however, these transplants finally died.

Besides the advantage that the application of Bordeaux mixture provided with respect to the bibit disease, some estates reported that beds treated with Bordeaux mixture experienced less nuisance from insects; the same had already been seen in the experimental fields.

Thanks to the benevolent answering of the questions posed, the data collected from the experimental fields and to which some possibly attach less value, since they have been obtained under conditions of care and supervision that are not always applicable in practice, received a more than satisfactory confirmation, especially for the application in practice at a large scale.

Several times it was said that one of the great dangers of the lay-out of the nursery beds in a large number together would be the rapid infection at an appearance of the *Phytophthora*. Had an estate only a few of these complexes with nursery beds and would the disease appear herein, then everything would be seen infected and [the estate would] be without planting material. By spraying Bordeaux mixture and by a correct management of the beds this danger can, however, be reduced to a minimum.

3.10. Final considerations

Following the results communicated in the foregoing pages it was proposed and recommended to prevent and control the bibit-disease, first to admit more air and light, either by taking away the shelters of the nursery beds at regular times, or by orienting the beds at the layout in such a way that the sun can enter generously during the largest part of the day.

Further, from their earliest youth, to spray the bibit regularly with Bordeaux mixture, when possible once in five days or otherwise after heavy rainfall or during moist weather. The best result of these proposed measures may be expected when the care of the planting stock is completely taken away from the field-coolies.

That such is possible and yields good results was demonstrated this year by one of the large companies which placed the lay-out of the nursery beds, in a few locations, under the immediate supervision of an employee.

In this way thousands of beds, close together, were laid out by separate coolies, a measure facilitating supervision.

These beds were sprayed regularly with Bordeaux mixture; sometimes indeed the bibit disease did appear, but it affected a few beds at most and did not spread. The planting stock obtained in this way not only developed quite evenly but also grew vigorously and struck root better than usual. When bibit is grown in this way it will also be possible to content oneself with a smaller number of beds per coolie than hitherto considered necessary. Furthermore, to reduce losses, the bibit that would be thrown away at thinning now can be transplanted. A measure which is quite certainly to the advantage of the planter.

In 1895, when for many estates the weather was very unfavourable during the lay-out of the beds, spraying Bordeaux mixture was applied nearly everywhere and people generally had changed the lay-out of the beds.[58]

Notwithstanding the unfavourable weather the bibit disease hardly appeared and the plague could be kept under control.

Where the *Phytophthora* did appear on a few estates and the disease here and there spread dangerously, it could certainly be attributed for the largest part to the poor control measures, insufficient care and inadequate supervision. One should never lose sight of the fact that preventive measures are preferable by far to any other kind of control. 'Better prevention than cure' should be the motto in Deli.

To resume in a few words what has been communicated in the foregoing pages we see,

that: *Deli is stricken by a disease in the bibit which made the harvest uncertain and did consider the future dark.*

that: *the cause of this bibit disease was shown to be the Phytophthora Nicotianae nov. spec.*

that: *by rational change of the nursery beds and spraying of the plants with Bordeaux mixture the disease can be counteracted in her appearance and spread.*

that: *by taking the correct preventive measures, by good care and supervision, the disease has lost her serious character and shows up only sporadically.*

The sad experience, went through by many at the appearance of the bibit disease, may stay as an example and urge everybody never to lose sight of caution. The *Phytophthora Nicotianae* always remains an enemy of the tobacco cultivation.

November 1895. J. van Breda de Haan.

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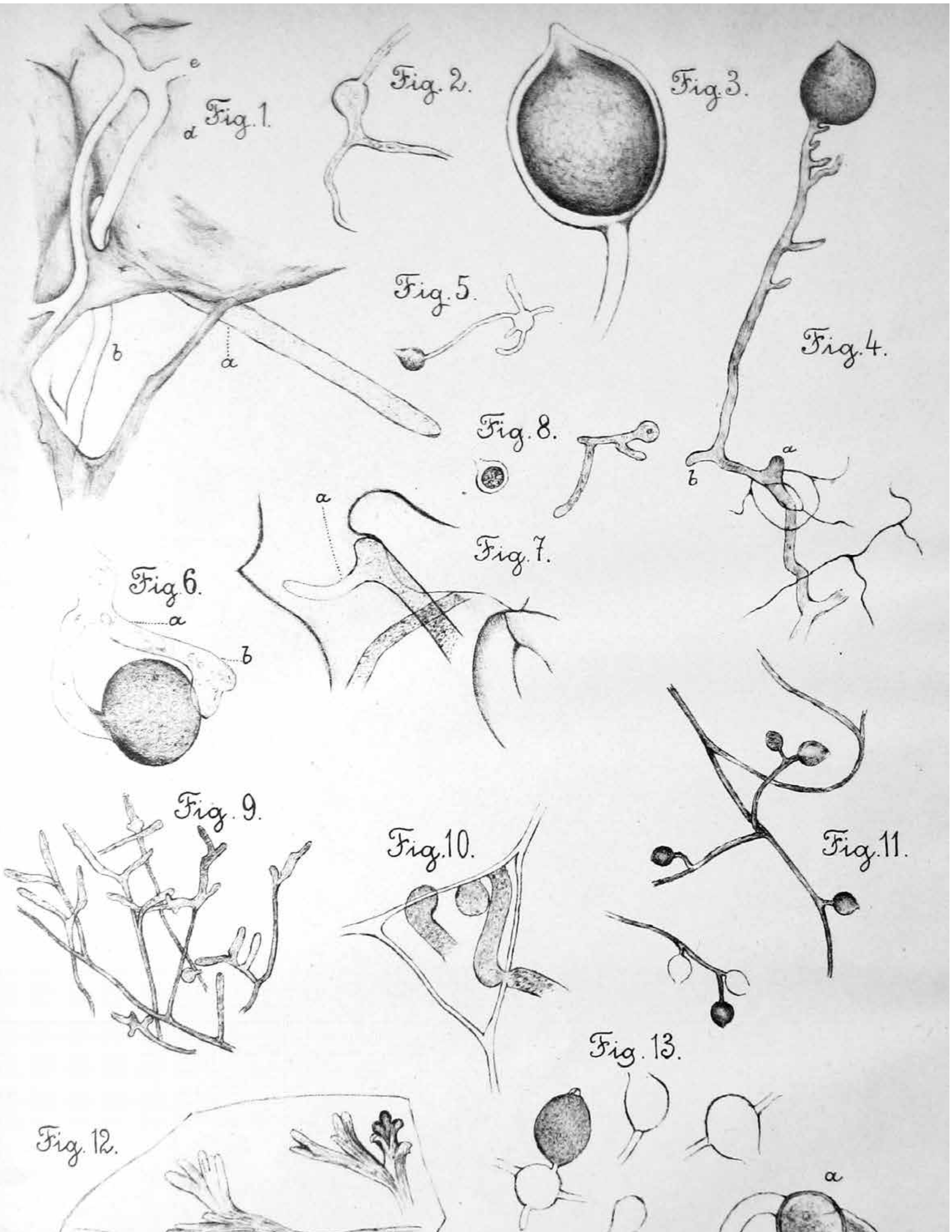
Figure 3.2 (next page). Illustrations of Phytophthora Nicotianae by van Breda de Haan (1896).



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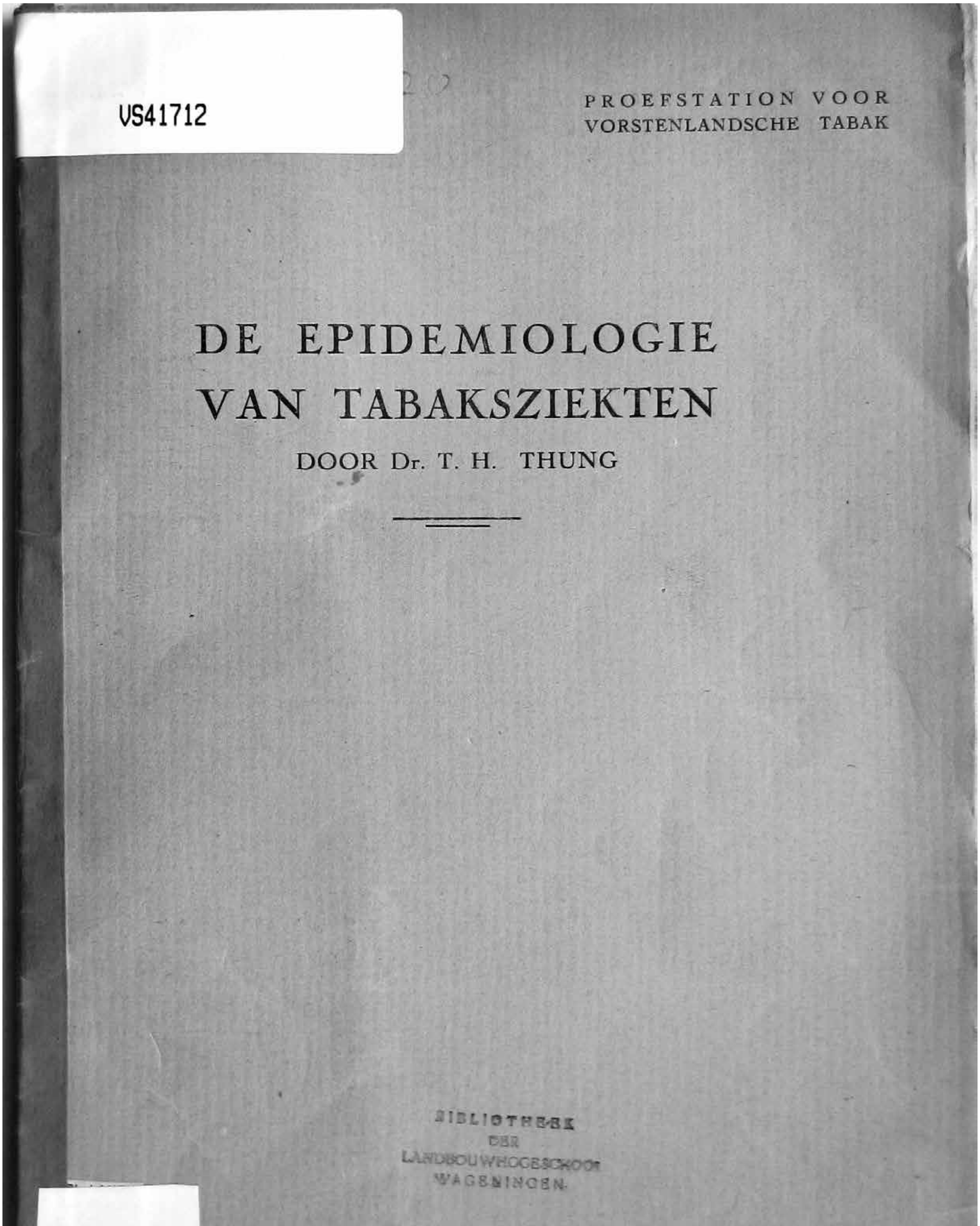


PROEFSTATION VOOR
VORSTENLANDSCHE TABAK

DE EPIDEMIOLOGIE VAN TABAKSZIEKTEN

DOOR Dr. T. H. THUNG

Chapter 4

The epidemiology of tobacco diseases

T.H. Thung

(Lecture presented on Tuesday, 28 April 1931 at Klaten)

4.1. Introduction

As soon as one knows in phytopathology the symptoms of a certain disease, the attention is first of all directed toward the pathogen and then to the way of transmission from plant to plant.[1]

Very much fine work, of great importance to agriculture and quite interesting to biology, has been performed in this respect; to mention only a few examples: the study on the transmission of the leaf roll disease of the potato plant by the aphid *Myzus persicae*. This [aphid] also happens to be able to spread the mosaic diseases of many plant species such as that of the sugar beet, the potato and the cucumber, but – curiously – not that of tobacco. Furthermore the finding of the strict specialisation of the transmission of the 'curly top' of the sugar beet by the cicada *Eutettix tenella*, of 'aster yellow' by the *Cicadula sexnotata*; then the study of the dispersal of the yellow stripe disease of the sugar cane by *Aphis maidis* with the peculiarity that just this insect rarely occurs on the sugar cane and only migrates thereto when the wild grasses in the environment are eradicated, whereas the *Aphis sacchari* common on sugar cane is not able to transmit the yellow stripe disease.

Furthermore the studies on the transmission by bark beetles of fungi parasitic on trees; etc. etc.

In addition to the generally adopted methods of phytopathological research it seems to me to be not without importance to bring forward another method as a supplement: that of the epidemiology.

Under an epidemic we must understand the plants becoming diseased in large numbers, at which we must assume that the disease is introduced into the planting from the outside.

Fig. 4.1 (previous page). Title page of the 1931 paper by Thung Tjeng Hiang. Source: Library Wageningen University and Research Centre.

The opposite are the endemics, wherewith the disease is ever present in the planting, either in latent form, or at low level. Thus, an explosion of mildew on the rubber on a certain island can be called an endemic, when the fungus is present for years in the rubber plants of that island but does not come to any spread due to circumstances.

Theoretically one may comment that this is only a gradual difference of time, since it may be supposed that the plants were free from diseases at the very beginning. However, for the disease control it may make a great difference whether one has to deal with an epidemic or an endemic.

Fig. 4.2. A 'mosaic leaf'. E. Palm del. Source: Jensen (1920) Plate 17.

Hence, seed-borne diseases, by which the planting is infected from the first day, always form endemics.

4.2. Procedure

The present study considers the question whether at the epidemic appearance of diseases in a planting specific types exist in the way of spread, in other words whether an epidemiology can be formulated for each disease separately and also characteristic for that disease.

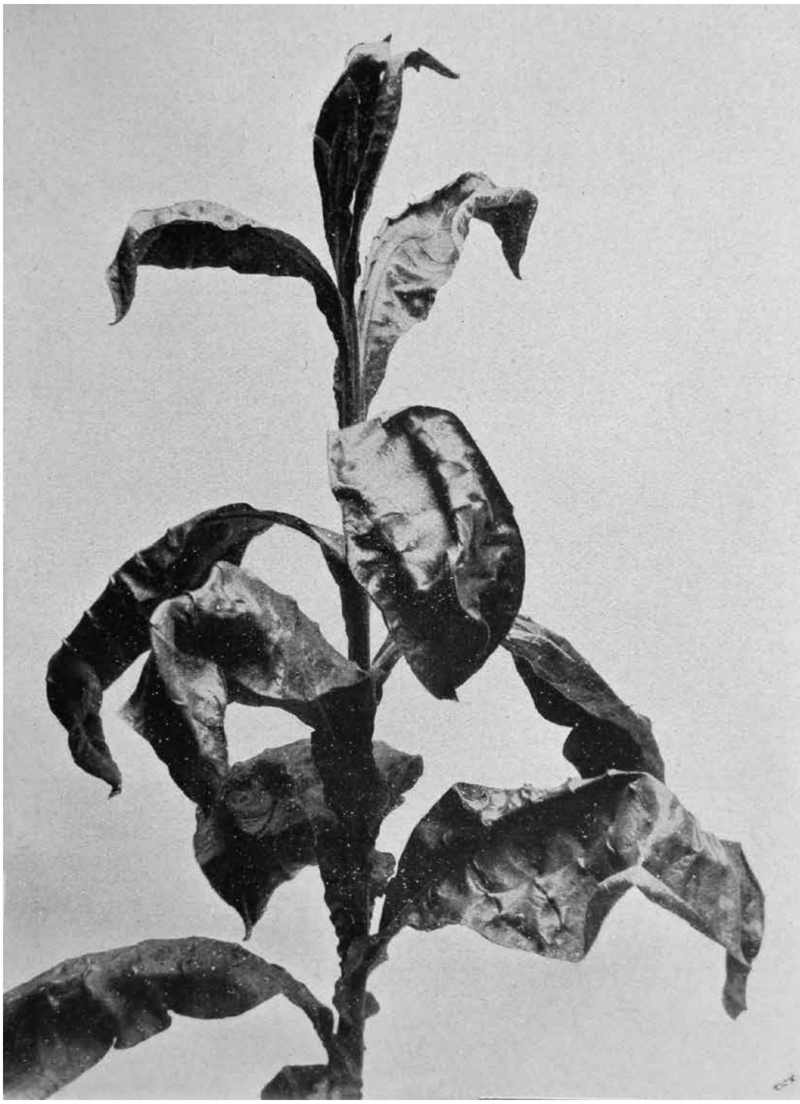


Fig. 4.3. The upper part of a 'kroepoek plant'[showing the 'curl']. Source: Jensen (1920) Plate 21.

The tobacco planting in the Principalities is pre-eminently suitable for this study. The first days, that the tobacco is in the field, we deal with a completely healthy planting. Not a single disease is transmitted with the seed sown, as shown by the annual control of the seeds from all estates by the Experiment Station for Principalities Tobacco.

Every disease, that now enters the planting, comes from the outside. Here we have to deal with three kinds of infection sources:

1st kind: the soil and the water.
2nd kind: the labourer.
3rd kind: the air.

The infection with *Phytophthora nicotianae* comes by way of the soil (and the water), and, the mosaic by way of the labourer, whereas the *kroepoek* disease [i.e. the curl] affects the plants through the air.

Though mosaic may, theoretically, enter the planting also in other ways it is my conviction that for the large practice only infection by way of the labourer is of importance (Fig. 4.2).

The curl requires some more explanation. The leaves of the diseased plants are characterized by an irregular, twisted surface, where the secondary and tertiary veins show thickenings that can grow into secondary leaflets (Fig. 4.3). These symptoms can be transferred by grafting but not by sap. The disease occurs locally along *dessa* borders; she depends on the location but not on the soil type. If plants in pots filled with sterilized soil are placed along infested *dessa* borders, they will get the curl; if, inversely, soil from infested sites is put in pots in the open field, the plants placed in these pots will remain healthy.

Thus, the infection of the plants passes by way of the air, either by insects or by other factors. Research on this point is ongoing so that a definitive answer cannot yet be given.

To follow the course of the spread of the diseases a planting has been mapped. As much as possible the diseased and healthy plants are recorded within one day's time. This inspection is done at regular times so that the plants which became diseased in the interval are known exactly.

4.3. The methods of calculation

The course of the disease (fig. 4.4 – 4.7] spread can now be expressed in different ways. For the accompanying graphs the method is used in which the number of newly infected plants during a certain interval is expressed in percentages of the total number of plants that were still healthy at the beginning of the interval [Box 4.1]. In this way a measure of infection size during the relevant interval is obtained. This figure divided by the number of days of the interval yields the 'daily infection size' ('*dagelijkse infectiegrootte*'), assuming herewith that the infection during the interval was regular.

For those interestees only, who wish to check the figures, the more elaborate information given below is useful [tables 4.1 – 4.4]. As an example we consider the following observations: On the Doekoehan field of estate Ngoepit, section IV, an experimental planting of 2164 plants was planted on 21 August 1930 [table 4.1]. So these plants were healthy. The first inspection took place on 26 September, that is after 36 days. Hereby 73 plants were found to be killed by Phytophthora, whereas among the remaining 2091 plants 23 had mosaic and 110 had the curl. Now the question rises against which number the percentage diseased plants has to be expressed. For mosaic and curl the 2091 living plants should be taken as the reference value, because among these plants it was counted how many had mosaic and curl. For Phytophthora the number of planted plants 2164 should be used to obtain a reference number ('*basisgetal*') in which the number of diseased plants is included.

Calculating in this way we obtain the following infection values at the first inspection:

for mosaic	1.10 %	or per day 0.031 %
for curl	5.26 %	or per day 0.146 %
for Phytophthora	3.37 %	or per day 0.094 %

The second inspection took place on October 13th, that is 17 days after the first, when 7 plants were found to be killed by Phytophthora, whereas among the remaining 2084 plants 8 were found to be newly diseased by mosaic and 48 by curl.

The calculation of the infection size during the past 17 days uses the following reference number: For mosaic 2084 minus the 23 mosaic plants of the first inspection = 2061 and for curl 2084 minus the 110 curly plants of the first inspection = 1974, whereas for phytophthora 2091 is the reference number to calculate the percentage of newly affected plants. We may introduce an error in the reference number for curl and mosaic, since it is possible that among the dead plants mosaic and curl diseased plants of the foregoing inspection were already included so that from 2084 among the dead ones a part of 23 for mosaic was deducted and also a part of 110 for curl, as a result of which the reference numbers 2061 and 1974 may be too small.

It would be better to check each time on the map how many of the dead plants were diseased by mosaic and curl. In the following calculation this was not done in order to work faster, considering that the errors made can be neglected for our considerations.

So, we obtain the following result from the second inspection:

for mosaic	0.39 %	or per day 0.025 %
for curl	2.43 %	or per day 0.143 %
for Phytophthora	0.34 %	or per day 0.020 %

In this way we arrive at values called above 'daily infection size during a certain inspection interval'; these are entered in the accompanying tables in the columns A.

Two other methods of calculation are elaborated in the columns B and C, both calculations in percentages of the original number of plants, which has the advantage of a constant reference number but which does not provide a correct picture of the infection size from inspection to inspection.

In the columns B the diseased plants newly found are expressed as percentages of the original number of plants and divided by the number of days of the relevant interval. For the above mentioned Doekoehan field the value for mosaic at the second inspection is 8 divided by 2164 = 0.37 %. This [figure], divided by 17 days, yields a per day value of 0.022 %. The colums C give the total number of diseased plants after each inspection, which is in case of mosaic 23 + 8 = 31 plants, or a percentage of 1.43 of 2164 plants. This results in a per day value of 0.027 %, i.e. 1.43 divided by 36 + 17 = 53 days, adding up the number of days of the two intervals.

4.4. Results

Whatever the method of calculation the result is quite characteristic, [namely] that the three diseases mentioned above all have their own mode of spread. The accompanying graphs, rendering the 'daily infection size' of the colums A, show the rapid spread of mosaic.[2]

This is an avalanche-like extension during the later intervals. The mosaic line demonstrates the great infectivity of mosaic and the critical period of heavy infection toward the end of the second month after planting.[3] The line also shows that a plant diseased by mosaic is an infection focus for the surrounding plants so that a snowball-like spread occurs.[4]

The curl line has a completely different course. She varies within much narrower limits. The impression is created that the infection size tends to be constant during the whole growing season. Here, a diseased plant apparently is not a menace to the surrounding plants. This throws a curious light on the mode of infection for which today there is no explanation yet. Certainly, one has to do with a constant factor acting from outside, which tends to remain at regular strength.[5]

Fundamentally different again is the behaviour of Phytophthora. Its capricious nature is seen in 4 of the 6 graphs. After a considerable spread a decrease can occur, to be followed in turn by a still greater spread. The Phytophthora line shows indeed that the infection size must depend on all sorts of circumstances. Some factors we know; to mention a few: the infestation level of the soil, the humidity of the soil, and the rainfall. With the last factor the way in which the droplets fall down is not irrelevant. With more soil particles splashing up we get also more Phytophthora lesions on the leaves. These expand very fast so that the fungus can penetrate the stem within a short time, by which the whole plant dies.

This subject however: 'Phytophthora and circumstances' is a study on itself.[6]

The foregoing observations now provide sufficient proof that from the epidemiology valuable information can be collected about the properties of the infectants themselves, and also about disease control.

Box 4.1. Translator's explanation of tables and figures

Tables 4.1 – 4.4.

4.1.	Estate Ngoepit,	field Doekoehan,	planted 21 August	1930
	Top:	Section No. IV.		
	Bottom:	Whole experimental field.		
4.2.	Estate Sporogedoog,	field Prambanan.		
	Top:	Planting I,	planted 29 August	1930
	Bottom:	Planting II,	planted 15 September	1930
4.3.	Estate Gajamprit,	field Gathak,	planted 23 September	1930
4.4.	Estate Ngoepit- Djonggrangan,	field Babadan, planting III,	planted 3 October	1930

The tables consist of a left side narrow column and three similar sections. The left side column contains:

- Total number of plants planted (e.g. 2164), and
- four inspection dates with number of living plants present.

The section headings should be read as follows:

Mosaic						
New cases per inspection					Total increase of diseased plants in % of total number of planted plants	
Number	In % of plants present per inspection		In % of plants planted			
	Following each new inspection interval	A per day	Following each new inspection interval	B per day	Following each new inspection interval	C per day
23	1.100	**0.031**	1.063	**0.030**	1.063	**0.030**
8			*etcetera*			

Figures 4.4 – 4.7.

ordinate – number of plants affected
abscissa – time in days (illegible)

Drawn lines	mosaic	always near-exponential growth of epidemic.
Broken lines	curl	more or less constant influx.
Dotted lines	Phytophthora	irregular growth of epidemic, sometimes explosive.

Pages 108-111 reproduce Tables 4.1-4.4

ONDERNEMING NGOEPIT, tuin DOE KOEHAN, UITGEPLANT 21 Augustus 1930.

Aanwezige planten	MOZAIEK							KROEPOEKZIEKTE							PHYTOPHTORA AANTASTING						
Vak No. IV. Bij uitplanten 2164.	Bij elke inspectie nieuwe gevallen					Totale toename van zieke planten in % van de uitgeplante		Bij elke inspectie nieuwe gevallen					Totale toename van zieke planten in % van de uitgeplante		Bij elke inspectie nieuwe gevallen					Totale toename van zieke planten in % van de uitgeplante	
	Aantal	in % van de dan telkens aanwezige gezonde planten		in % van de uitgeplante planten				Aantal	in % van de dan telkens aanwezige gezonde planten		in % van de uitgeplante planten				Aantal	in % van de dan telkens aanwezige gezonde planten		in % van de uitgeplante planten			
		na elke nieuwe controle periode	A per dag	na elke nieuwe controle periode	B per dag	na elke nieuwe controle periode	C per dag		na elke nieuwe controle periode	A per dag	na elke nieuwe controle periode	B per dag	na elke nieuwe controle periode	C per dag		na elke nieuwe controle periode	A per dag	na elke nieuwe controle periode	B per dag	na elke nieuwe controle periode	C per dag
Bij 1e inspectie 26-9-'30.- 2091.	23	1.100	0.031	1.063	0.030	1.063	0.030	110	5.261	0.146	5.083	0.141	5.083	0.141	73	3.373	0.094	3.373	0.094	3.373	0.094
Bij 2e inspectie 13-10-'30.- 2061.	8	0.390	0.023	0.370	0.022	1.433	0 027	48	2 432	0.143	2.218	0.131	7.301	0.138	7	0.335	0.020	0.323	0.019	3.697	0.070
Bij 3e inspectie 27-10-'30.- 2043.	19	0.930	0.066	0.878	0.063	2.311	0.035	53	2.766	0.198	2.450	0.175	9.750	0.146	10	0.480	0.034	0.462	0.033	4.159	0.062
Bij 4e inspectie 10-11-'30.- 1894.	68	3.590	0.256	3.142	0.224	5.453	0.067	38	2.193	0.157	1.756	0.125	11.506	.0142	130	6.268	0.448	6.007	0.429	10.166	0.126
Totaal proefveld Uitgeplant 7005.																					
Bij 1e inspectie 26-9-'30.- 6710.	51	0.760	0.021	0.730	0.020	0.730	0.020	229	3.413	0 095	3.270	0.097	3.270	0.097	195	2.784	0.077	2.784	0.077	2.784	0.077
Bij 2e inspectie 13-10-'30.- 6641.	24	0.361	0 021	0.342	0.021	1.071	0.022	147	2.310	0.136	2.099	0.123	5.368	0.113	18	0.268	0 016	0.257	0.015	3.047	0.058
Bij 3e inspectie 27-10-'30.- 6574.	48	0.730	0 052	0.686	0.056	1.756	0 026	174	2.819	0.201	2.483	0.177	7.851	0.122	43	0.643	0.046	0.613	0.044	3.655	0.055
Bij 4e inspectie 10-11-'30.- 6234.	237	3.802	0.272	0.329	0.024	2.083	0.025	140	2.456	0.175	2.000	0.143	9.850	0.122	298	4 482	0.320	4.254	0.339	7.909	0.098

ONDERNEMING SOROGEDOOG, tuin PRAMBANAN, AANPLANT I UITGEPLANT 29 Augustus 1930; AANPLANT II UITGEPLANT 15 September 1930

Aanwezige planten	MOZAIEK							KROEPOEKZIEKTE							PHYTOPHTORA AANTASTING						
	Bij elke inspectie nieuwe gevallen					Totale toename van zieke planten in % van de uitgeplante		Bij elke inspectie nieuwe gevallen					Totaal toename van zieke planten in % van de uitgeplante		Bij elke inspectie nieuwe gevallen					Totale toename van zieke planten in % van de uitgeplante	
	aantal	in % van de dan telkens aanwezige gezonde planten		in % van de uitgeplante planten				aantal	in % van de dan telkens aanwezige gezonde planten		in % van de uitgeplante planten				aantal	in % van de dan telkens aanwezige gezonde planten		in % van de uitgeplante planten			
		na elke nieuwe controle periode	A per dag	na elke nieuwe controle periode	B per dag	na elke nieuwe controle periode	C per dag		na elke nieuwe controle periode	A per dag	na elke nieuwe controle periode	B per dag	na elke nieuwe controle periode	C per dag		na elke nieuwe controle periode	A per dag	na elke nieuwe controle periode	B per dag	na elke nieuwe coutrole periode	C per dag
Aanplant No. I Bij uitplanten 1460																					
Bij 1e inspectie 26-9-'30 1453	44	3.028	**0.104**	3.014	**0.104**	3.014	**0.104**	16	1.102	**0.038**	1.096	**0.038**	1.096	**0.038**	7	0.480	**0.017**	0.480	**0.017**	0.480	**0.017**
Bij 2e inspectie 10-10-'30 1409	95	6.742	**0.482**	6.507	**0.465**	9.521	**0.221**	33	2.296	**0.164**	2.260	**0.161**	3.356	**0.078**	—	—	—	—	—	—	—
Bij 3e inspectie 24-10-'30 1312	118	8.994	**0.642**	8.082	**0.577**	17.603	**0.309**	51	3.638	**0.260**	3.493	**0.250**	6.850	**0.120**	2	0.138	**0.010**	0.137	**0.010**	0.616	**0.011**
Bij 4e inspectie 7-11-'30 1127	471	41.792	**2.985**	32.260	**2.304**	49.863	**0.702**	44	3.427	**0.245**	3.014	**0.215**	9.863	**0.139**	67	4.618	**0.330**	4.590	**0.328**	5.205	**0.073**
Aanplant No. II Bij uitplanten 965																					
Bij 1e inspectie 26-9-'30 959	4	0.418	**0.038**	0.415	**0.014**	0.415	**0.038**	5	0.521	**0.047**	0.518	**0.047**	0.518	**0.047**	6	0.622	**0.057**	0.622	**0.057**	0.622	**0.057**
Bij 2e inspectie 10-10-'30 953	22	2.308	**0.165**	2.280	**0.163**	2.694	**0.108**	5	0.525	**0.038**	0.518	**0.037**	1.036	**0.041**	2	0 209	**0.015**	0.137	**0 010**	0.830	**0.033**
Bij 3e inspectie 24-10-'30 930	84	9.032	**0.645**	8.705	**0.622**	11.398	**0.292**	13	1.374	**0.098**	1.347	**0.096**	2.383	**0.061**	1	0.104	**0.007**	0.104	**0.007**	0.933	**0.024**
Bij 4e inspectie 7-1-'30 840	600	71.429	**5.102**	62.176	**4.441**	73.575	**1.388**	8	0.863	**0.062**	0.830	**0.060**	3.212	**0.061**	6	0.628	**0.045**	0.622	**0.044**	1.554	**0.029**

ONDERNEMING GAJAMPRIT, tuin GATHAK, AANPLANT II UITGEPLANT 23 September 1930.

Aanwezige planten	MOZAIEK — Bij elke inspectie nieuwe gevallen — Aantal	MOZAIEK — in °/₀ van de dan telkens aanwezige gezonde planten — na elke nieuwe controle periode	MOZAIEK — A per dag	MOZAIEK — in °/₀ van de uitgeplante planten — na elke nieuwe controle periode	MOZAIEK — B per dag	MOZAIEK — Totale toename van zieke planten in °/₀ van de uitgeplante — na elke nieuwe controle periode	MOZAIEK — C per dag	KROE — Bij elke inspectie — Aantal	KROE — in °/₀ van de dan telkens aanwezige gezonde planten — na elke nieuwe controle periode	KROE — A per dag	POEKZIEKTE — nieuwe gevallen — in °/₀ van de uitgeplaten planten — na elke nieuwe controle periode	POEKZIEKTE — B per dag	POEKZIEKTE — Totale toename van zieke planten in °/₀ van de uitgeplante — na elke nieuwe controle periode	POEKZIEKTE — C per dag	PHYTOPHTORA AANTASTING — Bij elke inspectie nieuwe gevallen — Aantal	PHYTOPHTORA — in °/₀ van de dan telkens aanwezige gezonde planten — na elke nieuwe controle periode	PHYTOPHTORA — A per dag	PHYTOPHTORA — in °/₀ van de uitgeplante planten — na elke nieuwe controle periode	PHYTOPHTORA — B per dag	PHYTOPHTORA — Totale toename van zieke planten in °/₀ van de uitgeplante — na elke nieuwe controle periode	PHYTOPHTORA — C per dag
Aanplant No. II Bij uitplanten 4817.																					
Bij 1e inspectie 15-10-'30. 4813.	48	0.997	**0.045**	0.997	**0.045**	0.996	**0.045**	16	0.332	**0.015**	0.332	**0.015**	0.332	**0.015**	4	0.083	**0.004**	0.083	**0.004**	0.083	**0.004**
Bij 2e inspectie 28-10-'30. 4759.	19	0.400	**0.031**	0.394	**0.030**	1.391	**0.040**	79	1.649	**0.127**	1.640	**0.126**	1.972	**0.056**	6	0.125	**0.010**	0.125	**0.010**	0.208	**0.006**
Bij 3e inspectie 11-11-'30. 4380.	127	2.900	**0.207**	2.636	**0.188**	4.027	**0.082**	75	1.723	**0.123**	1.557	**0.111**	3.530	**0.072**	360	7.490	**0.535**	7.474	**0.534**	7.681	**0.157**
Bij 4e inspectie 25-11-'30. 4074.	402	9.867	**0.705**	8.345	**0.596**	12.373	**0.196**	28	0.683	**0.049**	0.581	**0.042**	4.110	**0.065**	179	4.025	**0.288**	3.716	**0.265**	11.397	**0.181**

ONDERNEMING NGOEPIT-DJONGGRANGAN, tuin BABADAN, AANPLANT III UITGEPLANT 3 October 1930.

Aanwezige planten	MOZAIEK							KROEPOEKZIEKTE							PHYTOPHTORA AANTASTING						
Aanplant No. III Bij uitplanten 1423	Bij elke inspectie nieuwe gevallen					Totale toename van zieke planten in % van de uitgeplante		Bij elke inspectie nieuwe gevallen					Totale toename van zieke planten in % van de uitgeplante		Bij elke inspectie nieuwe gevallen					Totale toename van zieke planten in % van de uitgeplante	
	Aantal	in % van de dan telkens aanwezige gezonde planten		in % van de uitgeplante planten				Aantal	in % van de dan telkens aanwezige gezonde plante		in % van de uitgeplante planten				Aantal	in % van de dan telkens aanwezige gezonde planten		in % van de uitgeplante planten			
		na elke nieuwe controle periode	A per dag	na elke nieuwe controle periode	B per dag	na elke nieuwe controle periode	C per dag		na elke nieuwe controle periode	A per dag	na elke nieuwe controle periode	B per dag	na elke nieuwe controle periode	C per dag		na elke nieuwe controle periode	A per dag	na elke nieuwe controle periode	B per dag	na elke nieuwe controle periode	C per dag
Bij 1e inspectie 9-10-'30 1371	—	—	—	—	—	—	—	4	0.292	**0.049**	0.281	**0.047**	0.281	**0.047**	52	3.654	**0.610**	3.654	**0.610**	3.654	**0.610**
Bij 2e inspectie 21-10-'30 1366	1	0.073	**0.006**	0.070	**0.006**	0.070	**0.006**	5	0.367	**0.031**	0.351	**0.029**	0.632	**0.035**	5	0.367	**0.031**	0.351	**0.029**	4.006	**0.223**
Bij 3e inspectie 7-11-'30 845	21	2.485	**0.146**	1.476	**0.087**	1.546	**0.044**	10	1.195	**0.070**	0.703	**0.041**	1.335	**0.038**	520	38.348	**2.256**	36.543	**2.150**	40.548	**1.159**
Bij 4e inspectie 21-11-'30 656	42	6.402	**0.457**	2.952	**0.211**	4.498	**0.092**	9	1.366	**0.098**	0.632	**0.045**	1.968	**0.040**	168	20.241	**1.446**	11.806	**0.843**	52.354	**1.068**

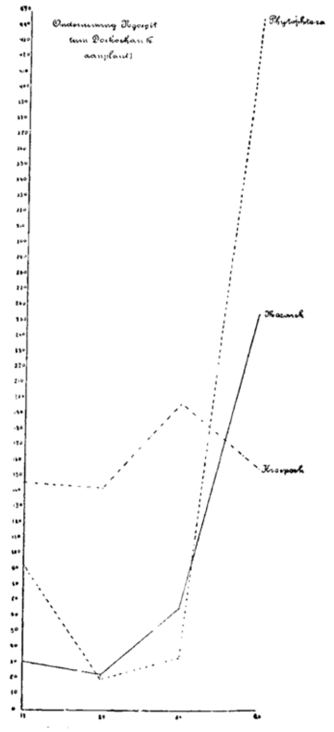


Fig. 4.4. 'Daily Infection Size' versus time.
Estate Ngoepit*, Field* Doekoehan*, section No. IV, planting I.*
Ordinate: Number of plants, highest value = 450.
Abscissa: Time in days, highest value = 45.[7]

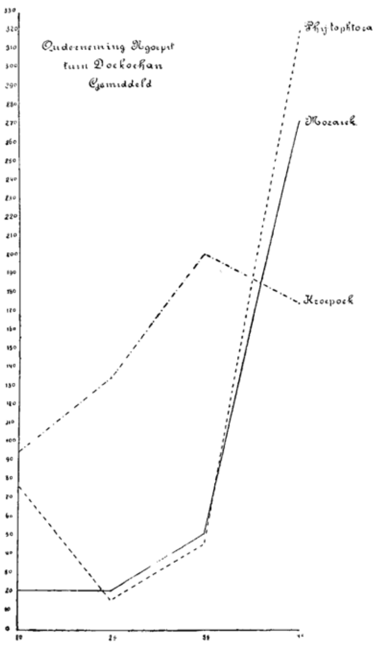


Fig. 4.5. 'Daily Infection Size' versus time.
Estate Ngoepit*, Field* Doekoehan*, Averaged.*[8]
Ordinate: Number of plants, highest value = 330.
Abscissa: Time in days, highest value = 45.

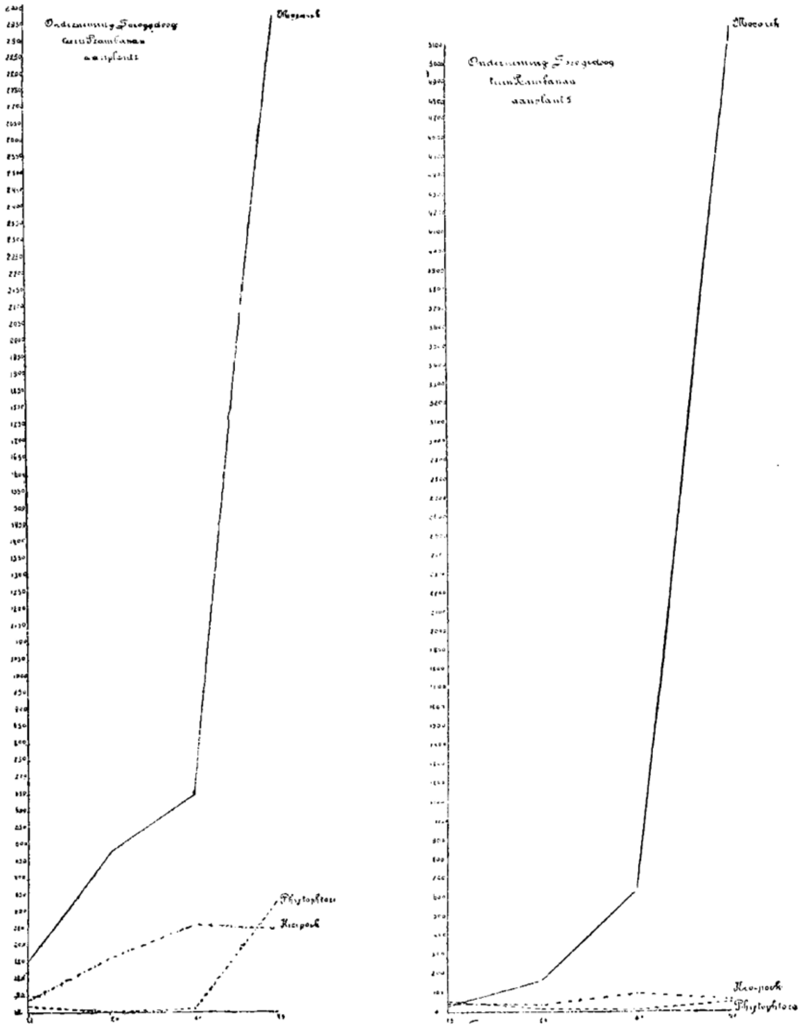


Fig. 4.6. 'Daily Infection Size' versus time.
Estate Sporogedoog, Field Prambanan, left: planting I, right: planting II.
Ordinate: Number of plants, highest value left = 2360, right = 2280.
Abscissa: Time in days, highest value left = 42, right = 42.

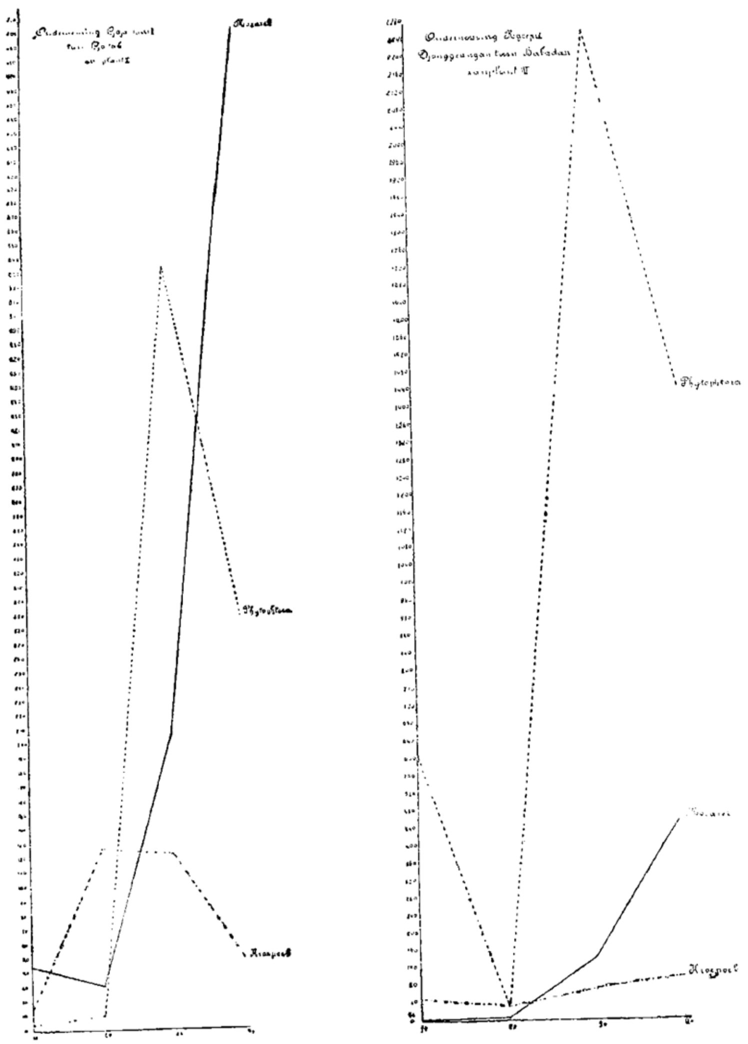
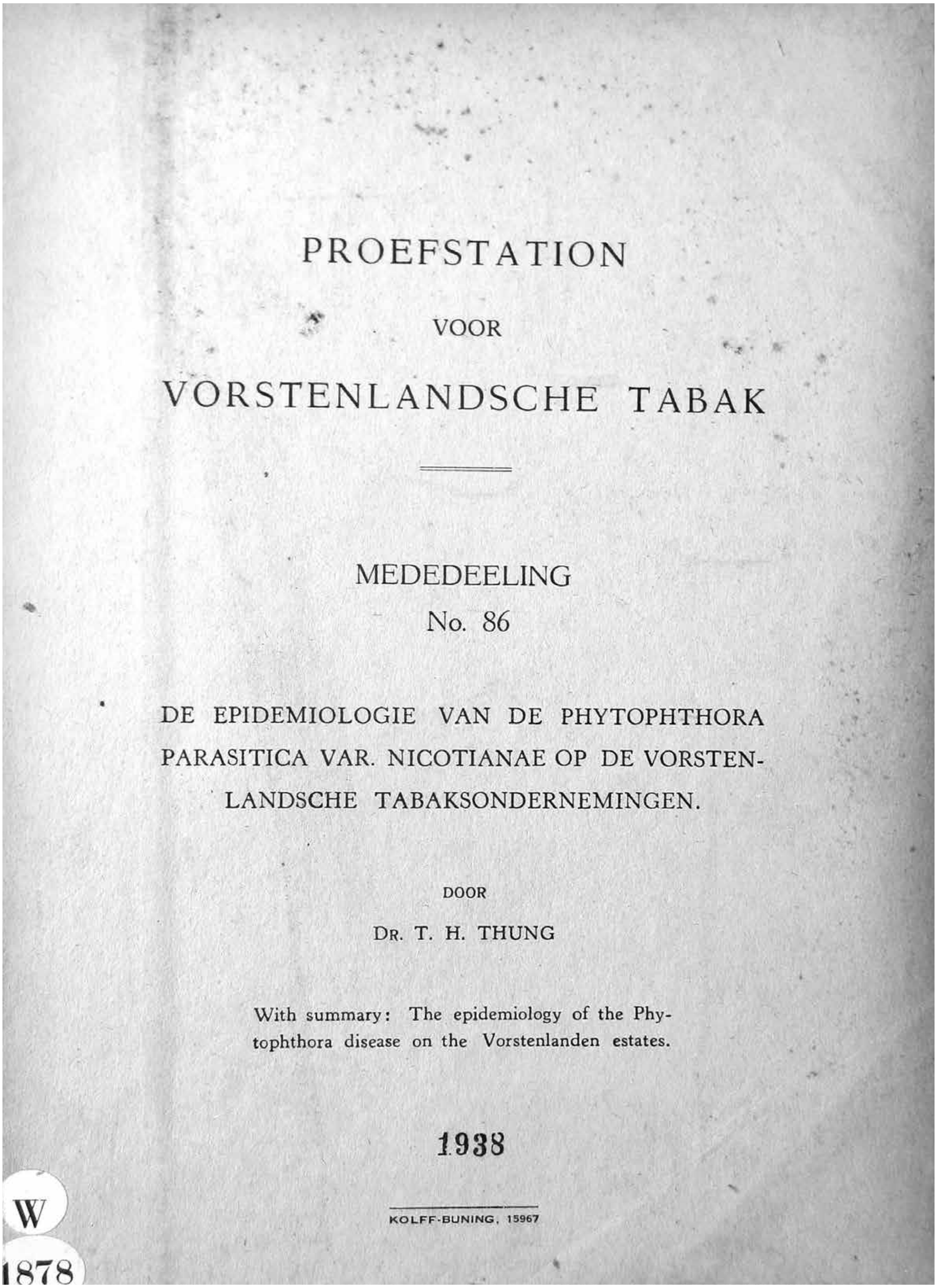


Fig. 4.7. 'Daily Infection Size' versus time.
Left: Estate G*AJAMPRIT*, *Field* G*ATHAK*, *planting II.*
Ordinate: Number of plants, highest value = 710 (?).
Abscissa: Time in days, highest value = 41.
Right: Estate N*GOEPIT*-D*JONGGRANGAN*, *field* B*ABADAN*, *planting III.*
Ordinate: Number of plants, highest value 2280.
Abscissa: Time in days, highest value = 73.



PROEFSTATION

VOOR

VORSTENLANDSCHE TABAK

MEDEDEELING

No. 86

DE EPIDEMIOLOGIE VAN DE PHYTOPHTHORA PARASITICA VAR. NICOTIANAE OP DE VORSTENLANDSCHE TABAKSONDERNEMINGEN.

DOOR

DR. T. H. THUNG

With summary: The epidemiology of the Phytophthora disease on the Vorstenlanden estates.

1938

KOLFF-BUNING, 15967

Chapter 5

Experiment Station
for
Vorstenlanden Tobacco

COMMUNICATION No. 86

THE EPIDEMIOLOGY OF THE PHYTOPHTHORA PARASITICA VAR. NICOTIANAE IN THE VORSTENLANDEN TOBACCO ESTATES.

BY

DR. T.H. THUNG

With summary: The epidemiology of the Phytophthora disease on the Vorstenlanden estates.

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Kolff-Buning

Figure. 5.1 (previous page). Title page of the 1938 paper by Thung Tjeng Hiang.

CONTENTS. **[present volume]**

5.1. Introduction

Though the *Phytophthora* at present no longer causes severe catastrophes on our estates, she still remains one of the most dangerous enemies of our tobacco. All too often one is surprised again by explosions of which the causes can be traced only after a lengthy search. In Communication No. 74 we already published the investigations performed up to 1932. Since then we could acquire a more detailed knowledge of the various causes of the *Phytophthora*-infections on the estates. During the past years we could elucidate many of the then still unknown factors by means of laboratory studies as well as field observations.

By planting ever more of the resistant variety Timor-Vorstenlanden the sources of infection will be blurred in the coming years. Nevertheless it remains necessary to document [the reasons] to which the infection-possibilities are to be ascribed, since theoretically it is not impossible that in the long run the *Phytophthora* will threaten the presently resistant tobacco variety once more. Examples of an increase in virulence are namely known also among fungi. With *Gloeosporium fructigenum*, a parasite of the bean, a changed virulence, appearing suddenly, has been observed by Muller (11). A similar change may be the cause that the Liberia coffee, which initially was resistant to the rust fungus *Hemileia vastatrix*, gradually became to suffer more from of this disease, as mentioned by Quanjer *c.s.* (14).

Besides abrupt changes properties of fungi could also be changed by hybridization; with smut fungi at least it is found that new combinations of properties and increase of virulence are possible in this way [Dickinson (6), Holton (7), Stakman and Christensen (16)]. With the *Phytophthora*-races mutual crossings (related to heterothallism) just as with the closely related *Peronospora parasitica*-fungus are a frequently occurring phenomenon [Leonian (10), De Bruijn (5)]. Though data about new races originated therefrom are hardly available, the supposition mentioned above, that our Timor-hybrids may be affected in the long run, is completely justified.

The knowledge of the ways of *Phytophthora*-dispersal and of her harmfulness would then show to be of great use for her control. On the basis of what we know about the epidemiology with the varieties presently susceptible, other measures could be brought in for further control, if needed. To this purpose we collected data in more or less detailed way on several estates during a few campaigns. Herewith we asked ourselves the following questions:

I. How does the infection enter the tobacco area?
II. To what degree can the risk of infection of a tobacco plant be calculated in advance? [1]
III. Can measures be taken to avert possible dangers of infection?

We have also set ourselves the objective to check whether the now already low mortality rates could be further reduced.

The data mentioned above, applying the results of the more theoretical study concerning the way of life of the fungus in the plant, the soil, the manure and the water, have provided the basis for drawing up the following proposed methods to further sanitation of the estates.

To recapitulate it be brought forward that – as the variety Timor-Vorstenlanden is not a 100 % resistant and in the long run could lose her resistance significantly due to the above mentioned factors – hygienic measures will always be needed.[2]

5.2. The behaviour of the fungus

5.2.1. The parasitism

According to the researches by Tucker (19) our tobacco-*Phytophthora* belongs to the *parasitica*-group and must be called *Phytophthora parasitica var. nicotianae*. To the same group should be reckoned the *Phytophthora* of *Solanum melongena* (Terong), *Ricinus communis* (Djarak) and *Manihot utilissima* (Ketella), among others. These fungus races cannot be distinguished from each other morphologically, but they differ in virulence. Whereas the other *parasitica*-species can attack tobacco only by way of exception, the tobacco-*Phytophthora* attacks the tobacco plant in all stages of development.

In their youth our Timor-Vorstenlanden-varieties can also be attacked by the tobacco-*Phytophthora*; however, the penetration into the plants of these varieties proceeds very slowly. In the practice of our estates we find at times Timor-Vorstenlanden-plants which show *Phytophthora*-flecks low at the stalk, but the plants do not experience noticeable disadvantages, since they usually could produce new roots on the stem parts above the lesion. In Communication No. 82 we published a photo thereof.

About the *nicotianae*-variety Tucker writes: 'Three isolations caused severe infections of apples, potatoes, eggplant fruits and seedlings and tobacco. They attacked tomato fruits slightly to severely, and varied from virulently to non-pathogenic to cotton balls, Ricinus seedlings and papaw seedlings.[3] They were weekly to non-pathogenic to tomato and cacao seedlings and citrus shoots' (p. 106). The inoculations meant here were applied to wounded plants.

Our experiments further show that the tobacco-*Phytophthora* can catch on in leaves of some other plants. When the fungus is applied to a wound, even more plants can be attacked by her, as shown in the table below:

Inoculated on 1/3/'37 **Examined on 5/3/'37**	**wounded**	**unwounded**
	* **	
Manihot utilissima Pohl	5/5 (¼-1 cm)	0/5
Eriodendrum anfractuosum D.C.	5/5 (1-2 cm)	0/5
Carica papaya L.	5/5 (~1 cm)	0/5
Hibiscus macrophyllus Roxb.	0/5	0/5
Jatropha Curcas L.	5/5 (2-3 cm)	1/5 (1-2 cm)
Ricinus communis L.	5/5 (3-4 cm)	5/5 (1-3 cm)
Tabernaemontana sphaerocarpa Bl.	0/5	0/5
Solanum melongena L.	5/5	0/5
Nicotiana tabacum L.	5/5 (6-7 cm)	5/5 (4-5 cm)

*) 5 out of 5 infections successful.
**) diameter of resulting flecks after 4 days.

Table 5.1. Inoculation experiments with mycelium of Phytophthora parasitica var. nicotianae on 5 spots at the underside of the leaves.

The resulting flecks are largest with the tobacco, then follows *Ricinus communis*; after tobacco this [species] is easiest to infect with our *Phytophthora*; such is far less the case with the *Jatropha Carcas*.

When sufficiently developed the tobacco plant itself can only be attacked by the tobacco-*Phytophthora*. Even after wounding the inoculations with other *Phytophthora*-species fail to do so.

This observation finds its confirmation a.o. in the studies by Tucker (19, p 175).

5.2.2. The saprophytism in the soil

Muller (12) showed for the pepper-*Phytophthora* that this fungus can survive in soil for a considerable time, with or without being mixed with parts of pepper plants. Earlier already other researchers established the saprophytic existence of *Phytophthora*-species, as did Miss de Bruijn (4) for *Phytophthora syringae, Phytophthora erythroseptica* and *Phytophthora infestans*. Through her research Miss de Bruijn came to the conviction that it is no exception in the genus *Phytophthora* but the rule, that the fungi can survive in the soil. The idea of some researchers, that this survival would be possible only in a quiescent stage, i.e. as oöspores, should rather be abandoned; moreover, of many species oöspores have never been found in nature. Toxopeus (18) gave a detailed study of the saprophytism of the djeroek-*Phytophthora*, where the influences of temperature and humidity on the life processes were examined too.

For the tobacco-*Phytophthora* several scientists made it plausible that she can survive in the soil [d'Angremond (1), van Breda de Haan (3), Jensen (8), Nolla (13), Thung (17)]. As, however, the growth of the fungus in the soil has not yet been studied in a satisfactory manner, a further study in this respect seemed important to me for a more complete explanation of the occurrence of the infections on our tobacco estates.

The moisture content, the loss on ignition and the organic carbon (the latter using the potassium-permanganate method of Ischtscherekow) were determined in samples from 4 different soil types generally occurring in the Vorstenlanden. The data obtained herewith (table 5.2) show that the organic matter present varied strongly as did the moisture content.

Soil type	% moisture	% loss of ignition	% C
Silt	1.8	2.75	0.11
Sand	1.6	3.25	0.14
Clay	6.8	12.65	0.41
Loam	7.2	13.63	0.43

Table 5.2. Composition of the soil samples.

Samples of these soils were mixed with water to [make] a slurry, put in culture tubes and sterilized. The moisture content thus became much higher than in the original situation. These various tubes were inoculated in 2 ways with *Phytophthora parasitica var. nicotianae* grown in tubes with oatmeal, i.e. with mycelial fragments and with zoöspores.

Some weeks later it turned out that in both cases mycelial growth had taken place and the presence of sporangia was observed.

At the outgrowth in water, as is often the case with inoculations by zoöspores, since these have to be transferred in water, a thickset and branched mycelium was observed. Even on the first soil type, with the lowest content of organic material, a good growth of mycelium and the formation of chlamydospores could be observed after 8 to 9 days.

Herewith the further proof is given for our tobacco-*Phytophthora* that this fungus can develop completely in the soil types mentioned above. Consequently, the soil of our tobacco areas, consisting of a combination of these types, forms a good substrate for the fungus when circumstances are favourable.[4]

Owing to this we must correct our opinion voiced in the publication of 1932 (17) that the *Phytophthora*'s possibility to subsist in the soil beyond the tobacco time should not be considered very great. This is correct only, when we include the counteracting factors that will be discussed later.

5.2.3. The formation of zoöspores

The swarming of the spores has been studied in detail by Toxopeus (18) with the *Phytophthora* of the Citrus, while Muller (12) did the same with the *Phytophthora* of the pepper. Apparently it is rather simple at Indian temperatures to bring about the detachment of the spores from sporangia, especially when the fungus is stimulated by a temperature shock. So the spores come loose when dishes with Petri-solution, in which mycelial tufts are present, are opened suddenly and placed before an open window (Toxopeus). Nor is it difficult to obtain swarm-spores with our tobacco-*Phytophthora*. In 1898 already Raciborski (15) wrote that one could very easily force the fungus into forming zoöspores, namely by washing away the nutrient solution in which she is grown and transferring the fungus to pure water. During our studies it appeared that, after 2 to 3 weeks under laboratory conditions, cultures on oatmeal and on rice show a rich production of sporangia which after transfer to a drop of water, with or without cooling, soon release zoöspores. Per sporangium 25 to 30 spores were counted, rarely 18. Very clear is the tendency of the zoöspores to move to the outside of the water droplet, probably because of a strong oxygen need. The study on the swarming was performed as follows: A fragment of mycelium with sporangia was placed in a water droplet on a cover slip, and with a ringlet of glass glued onto a microscope slide, so that sufficient air was at the disposal of the hatched spores. Some minutes later the droplet was checked under the microscope for the swarming of the spores and then the whole was or was not cooled. This was done by immersion in an isolated tank with ± 10 litres water of a certain temperature or by placing in an icebox.[5] Some of the cases studied are rendered in Table 5.3.

From the foregoing it appears that in many cases the contact with sufficient water is already occasion to produce zoöspores. In other cases, however, a temperature shock is needed. Repeated temperature shocks on different days can originate repeated swarms. With the cases 11, 12 and 13 a temperature cooling of 4.5 °C during 5 to 30 minutes apparently was not sufficient to let the spores swarm, but a cooling of 6 °C during 45 minutes [worked].

5.2.4. The infection capacity of the zoöspores.

The water, in which the spores were released, was transferred droplet-wise by means of sterile pipettes into tubes and Erlenmeyers with oatmeal agar, plum agar, or with the above mentioned soil types and on tobacco leaves in Petri dishes. In the latter case either the lower or the upper sides were provided with droplets. In all tubes and Erlenmeyers the zoöspores came to further growth.

On the tobacco leaves, however, infection took place only when inoculated at the lower sides.

No.	Culture		Initial temp. in °C	Liberation without temp. shock	Liberation with temperature shock	
	Age in days	Media				
1	32	*Oatmeal*	27.0	++		
2	60	″	28.5	-	5 min at 13.0 °C	- *a)*
3	60	″	28.5	-	3¾ hour at temp. varying from 18-27.0 °C	- *a)*
4	33	″	27.0	++		
5	35	″	27.0	++		
6	91	″	27.0	-	5 min at 18.5 °C	-
7	15	*Terong*	27.0	- *b)*		
8	16	″	27.5	-	10 min at 17.5 °C	+++ *d)*
9	16	″	27.5		5 min at 19.0 °C	++ *d)*
10	16	″	27.5		5 min at 16.0 °C	+++ *d)*
11	16	″	27.5		5 min at 23.0 °C	- *c) d)*
12	16	″	27.5		10 min at 23.0 °C	- *c) d)*
13	16	″	27.5		30 min at 23.0 °C	- *c) d)*
14	18	*Oatmeal*	27.5	++ *e)*		
15	18	″	27.5	++		
16	13	″	27.5	+++ *f)*		
17	13	″	27.5	++++		
18	13	″	27.5	++++		

a) cultures probably too old; most sporangia already germinated with tube; those ungerminated remained inactive.
b) very many ungerminated sporangia present.
c) on the next day these preparations were placed at 21.5 °C during 45 min., whereupon very strong swarming of spores followed.
d) The 6 preparations 8, 9, 10, 11, 12 and 13 were, 2 days after transfer to water droplets, cooled again during 1 hour at 18 °C. Again a rich swarming occurred, probably from sporangia meanwhile formed anew.
e) 4 of these preparations were cooled after 4 hours, when the zoöspores formed in the beginning had already germinated; respectively during 10 min. at 18 °C, 25 min. at 18 °C, 35 min. at 22.5 °C and 1 hour at 22.5 °C. In many not yet germinated sporangia spores were formed which, however, could not swarm outside.
f) Many of these sporangia had already germinate with a small tube. The next day the water of these preparations was refreshed; then cooling was applied (resp. 20, 40 and 110 min. at 19 °C), but no new spore swarms were obtained.
With some preparations coming from old oatmeal-cultures oöspores were found.

Table 5.3. The liberation of zoöspores.

The colonies on plum agar were compact and moist reminding one of yeast colonies. The mycelium formed here was stocky and strongly branched, but the resulting sporangia did not, however, differ from those formed on oatmeal, a medium on which mycelium is formed profusely. The growth on the different soil types took place, when this occurred in the water carried along – as already mentioned before, – in the form of stocky and strongly branched threads. During the growth over the moist soil fine crystal and silt particles became attached to the mycelium. The formation of sporangia on these mycelia was observed after about 2 weeks; in an examination 33 days after inoculation, the formation of sporangia was even lavish. In table 5.4 the results of the inoculations on the leaves are taken down.

Infection of the tobacco leaves apparently is rather difficult, also by way of the lower sides, when one considers the very large number of oöspores applied. The difference between success and failure of the infections at the lower and upper sides of the leaves probably has to be attributed to the greater and lesser presence of stomata. At the lower sides of full grown leaves of potted plants 150 to 200 stomata per mm^2 could be counted and at the upper sides some 40 to 60.

In addition the more or less open state of the stomata will be of influence. To check up on this drops with zoöspores were applied at different points in time to the rear sides of almost equally old leaves of several potted plants. To this end the plants were brought into the laboratory at 4 o'clock in the afternoon, at 11 in the evening, at 6 and at 10 in the morning, after which in each case 4 leaves were inverted by means of clips and provided with droplets on the lower sides now lying upwards. The state of the stomata appeared to be different at the various points in time according to a test with collodion, but as the germination of the zoöspores took place only 3 to 4 hours later, it could not be ascertained whether the threads growing from the zoöspores could profit from these differences. Under the water droplets the stomata of the various leaves might well be closed after some time, as also confirmed by an examination.

Accordingly, the number of successful infections was quite low, though the zoöspores were fit in view of the fact that the control-zoöspores in oatmeal tubes caught on well. In addition, many older leaves were inoculated with zoöspores

		18/7/'37	19/7/'37	20/7/'37	21/7/'37	22/7/'37	23/7/'37	24/7/'37
A	*upperside*	-*	-	-	-	-	-	-
B	*underside*	-	-	1 fleck	3 flecks	3 flecks	3 flecks	3 flecks
C	*upperside*	-	-	-	-	-	-	-
D	*underside*	-	-	3 flecks	4"	4"	4"	confluent flecks
E	*upperside*	-	-	-	-	-	-	-
F	*underside*	-	-	-	-	-	-	-
G	*upperside*	-	-	-	-	-	-	-
H	*underside*	-	1 fleck	2"	2"	2"	4"	4 flecks
I	*underside*	-	1 fleck	4"	5"	5"	7"	confluent flecks

* - means no flecks.

Table 5.4. Inoculation experiments with at every turn 80 drops with zoöspores on tobacco leaves in Petri dishes at 17/7/'37.

at their lower sides, because these – as will appear later – are more susceptible to *Phytophthora*-infections than the younger leaves. Table 5.5 shows the results of the inoculations:

Time of inoculation	Number of drops	18/1/'38	19/1/'38	20/1/'38	21/1/'38
15/1/'38, 4 in the afternoon	52	0	0	0	0
Idem, check in Petri dishes	68	0	0	0	1 fleck
15/1/'38, 11 in the evening	100	2 flecks	3 flecks	3 flecks	3 flecks
17/1/'38, 6 in the morning	100	0	0	0	0
17/1/'38, 10 in the morning	100	0	0	0	0
Idem, on old leaves	100	0	0	1 fleck	1 fleck

Table 5.5. Inoculations with zoöspores at the underside of not picked leaves.[6]

Though it took more than 10 hours before the water droplets had dried completely, the infection flecks happened to be quite few. Inoculations on leaves in Petri dishes succeed somewhat better according to Table 5.5, probably because they remained wet much longer.

The less successful result of the inoculations with zoöspores is contrary to the results of inoculations with bits of mycelium and sporangia, as shown by the following; from a culture tube of 20 days old 38 bits of mycelium with sporangia were applied to the upper sides of tobacco leaves in Petri dishes. After 2 days infections had appeared on 11 places, after 3 days on 25 places and after 5 days on all 38 places. At the lower sides of the leaves 17 pieces showed infection in 1 place after 2 days, in 6 places after 3 days and after 5 days infection in all 17 places. With these inoculations the success is almost equally easy at the upper as at the lower sides, also without wounding. Muller (12) found with the pepper-*Phytophthora* a similar difference between the infection capacity of the swarm-spores and that of the mycelium with sporangia.

With smears of soil, infected with tobacco-*Phytophthora* and well mixed, applied to the upper and lower sides of tobacco leaves we found for 16 leaves per case the following figures (in each case every leaf was infected with 100 ml soil mixture):

Infection upper sides: after 48 hours: 58 flecks; after 72 hours: 73 flecks.
“ lower sides: “ “ “ 44 “ ; “ “ “ 56 “

Thus the lower sides received more infections, possible through the presence of swarm-spores, which – as stated above – do not catch on by way of the upper sides.

On very old leaves inoculations succeed easier than on strongly growing leaves, as shown in the following experiment. On both types of leaves equal amounts of well-mixed infected soil were smeared; the numbers of leaves were chosen in relation to their size in such a way that in every case they together had nearly equal surfaces in the corresponding experiments. The resulting flecks were as follows: [7]

Very old leaves				fast growing leaves			
On	166	leaves:	531 flecks	on	64	leaves:	94 flecks
“	108	“ :	404 “	“	48	“ :	127 “
“	49	“ :	420 “	“	48	“ :	92 “

In summary we can conclude that under field conditions the zoöspores are not so much dangerous as direct attackers of the tobacco plants but rather as spreaders of infection over the fields. The mycelium fragments are equally dangerous in either case.[8]

5.2.5. The influence of climatological factors

By Toxopeus (18) and by Muller (12) it is demonstrated for the Citrus-*Phytophthora* and the pepper-*Phytophthora*, respectively, that climatological factors strongly affect the life processes. Drought and high soil temperatures weaken the fungus; in the dry season she will be found primarily in the more shadowy and moist places. Further it is also possible, according to Toxopeus, that the fungus withdraws into the deeper soil layers.

With the advent of the first rains the weakened fungus begins to revive and to form sporangia. During the beginning of heavy rain showers these will produce zoöspores, which will disperse with the water and spread the infection.

By his experiments with keeping infection-soil either dry or wet Jensen (9) made it probable for the tobacco-*Phytophthora* that for this fungus too the same effects apply of slowing down and promoting growth.

In the foregoing it was stated already that in the major soil types of our tobacco-areas the fungus can thrive under favourable conditions and proceed to the formation of sporangia; the following makes certain that the temperature and humidity fluctuations, which determine the afore-mentioned process of rise and decline of the spread of the fungus, also can be encountered again under our culture-conditions.

Which temperatures are damaging was studied as follows: 15 tubes with Thaxter-agar, inoculated two days before with tobacco-*Phytophthora*, were placed in a thermostat, of which the temperature gradually increased in 5 hours' time from 35 °C to 50 °C. At temperatures of 38 °, 42 °, 44 ° and 50 °C three tubes per case were taken from the thermostat and brought to normal room temperature, where the heating was regulated so that the respective tubes stayed at the various temperatures (with deviations within 3.4 °C) during one hour.

After a few repetitions (also with cultures on rice), at which other temperatures (45 °. 47 °, 48 °, 49 °) were applied too, the *Phytophthora*, after having been at room temperature during a few days, showed to be able to grow again, except those exposed to 50 °C. Here they showed no growth anymore even after 30 days.

The cultures exposed to the temperatures 48 ° and 49 ° showed a clear impairment as it took well over a week before the fungus in these tubes clearly resumed growth. Heating during one half hour at 50 ° showed to be just not killing, whereas that during two hours at 49 ° is lethal. To examine the dying of the fungus in the soil it will be necessary to take into account the duration and the frequency of temperature effects as well as the drought. Temperatures considerably lower than 50 °C will be already disadvantageous to the fungus when long-lasting. For the djeroek-*Phytophthora* Toxopeus (18) arrives at the conclusion that it is necessary for the growth of the fungus that the soil temperatures surpass 37 °C only by exception; for the formation of sporangia about the same requirements can be stated.

The effect of the drought appears from the following: tubes with the afore-mentioned different soil types, inoculated with zoöspores on 17/7/'37, showed on 30/9/'37 to contain virulent *Phytophthora*, in view of the flecks which the fungus caused on tobacco leaves. Similar tubes, which had been dried over chalk from 30/9/'37 to 30/10/'37, produced no flecks after smearing with water onto tobacco leaves. The next experiment also demonstrates the effect of drying out: 16 tubes with the 4 soil types were inoculated with *Phytophthora*-mycelium on 14/12/'36; the fungus took on rapidly and pervaded the soil; by storing them for 9 months in the laboratory the tubes dehydrated completely and the mycelium could be found again microscopically as pulverized fragments only. By sterile addition of water on 20/9/'37 some mycelium-growth could be observed in 3 tubes after 1½ month. The newly formed threads were rather thin and looked like those which grow from zoöspores. However, with these soils it was not possible to obtain infections on tobacco leaves. Neither succeeded this with tubes that had been inoculated with mycelium on 12/6/'37, of which the soil dried slowly. Smeared onto the reverse side of tobacco leaves on 28/1/'38 this soil did not give infection.

During the tillage rounds before the tobacco planting, when the opened soil lies fallow for a long time and is exposed to intensive drying, one obtains the same factors damaging to the fungus.

An impression of the temperatures attained in the ground is given by the following study.

Besides soils that were exposed to strong insolation as with the afore-mentioned circumstances, those that were continuously shadowed were studied also. In addition, various water points were incorporated in the study.

From 28/10/'36 to 19/10/'37 the temperature was measured every 10 to 13 days at the various sites, always at about 2 cm below the surface. Just like done by Toxopeus (18) with us the thermometer was also protected by a white paper case in order to prevent the rays of the sun affecting the rises of the mercury.

Site	Lowest temp.		Highest temp.		Sudden fall			Sudden rise		
	ºC	Date and time*	ºC	Date and time*	from ºC	to ºC	date and time span*	from ºC	to ºC	date and time span*
a	21.5	20/7/37/06	50.2	19/10/37/14	38.1	31.8	18/ 3/37/01-02	33.4	38.2	11/ 8/37/10-11
b	21.9	idem	51.5	19/10/37/13	33.5	29.5	Idem /01-02	31.9	39.4	20/ 8/37/ 9-10
c	21.1	idem	47.5	28/10/36/15	32.4	28.5	28/ 3/37/03-04	25.4	32.2	19/ 5/37/ 9-10
d	21.0	idem	39.2	idem	39.2	35.0	28/10/37/03-04	26.5	31.8	4/12/36/12-13
e	21.9	idem	39.4	28/10/36/15	39.4	35.0	28/10/36/03-04	31.6	39.3	28/10/36/13-14
f	20.5	30/7/37/06	41.2	18/12/37/12	34.6	29.4	18/ 3/37/01-02	26.9	33.6	10/ 1/37/ 9-10
g	20.5	idem	39.2	27/ 4/37/13	35.3	31.4	9/ 9/37/03-04	37.0	41.0	18/12/36/12-13
h	20.5	idem	41.0	18/12/36/13	34.2	31.7	9/ 9/37/03-04	33.7	37.5	18/ 2/37/11-12
i	21.3	11/8/37/06	40.0	29/ 2/37/13	36.4	32.0	28/ 9/37/02-03	30.5	35.9	28/12/36/10-11
j	21.2	30/7/37/06	37.9	27/ 3/37/13	36.3	33.5	28/ 9/37/02-03	30.9	36.3	28/ 9/37/12-13

* day/month/year/hours (from 1 to 24). The presentation of the table was slightly modified.

Table 5.6. The lowest and highest temperatures on record and the most pronounced falls and rises in temperature in soil and in water.

The soil sites were the following:

a. sandy, untilled soil. Vegetation: grass, which shrivels up completely in the dry season. No shadow.

b. garden soil rich in silt, that is tilled regularly; incidental shadow from thin shrubs.

c. soil with sawah (wet rice field), Crotalaria in the dry season. [9]

d. garden soil rich in silt and permanently shadowed, in a moist low lying place.

e. garden soil rich in silt and permanently shadowed, in a dry high lying place.

The water sites were the following:

f. streaming water in a conduct at a site with shadow during part of the day; rate of flow variable.

g. same conduct, at a site always without shadow.

h. same conduct, at a site with always light shadow.

i. same conduct, at a site always with heavy shadow.

j. standing water in a narrow circular drain usually in the shadow.

The readings were taken by day, every hour from 6 o'clock in the morning to 6 o'clock in the evening. The following table [table 5.6] renders the lowest and the highest temperatures in the year of observation as well as the most pronounced sudden temperature decreases and increases.

The mean temperatures of the 10 observation sites at 1 and 2 o'clock during the period 28/10/'36 – 19/10/'37, during the rainy season (taken as 28/10/'36 - 29/6/'37) as well as during the dry season (19/7/'37 – 29/6/'37), are entered in the following table [table 5.7]:

Place	Period * 28/10/36-19/10/37		Period ** 28/10/36-29/6/37		Period 12/7/37-19/10/37	
	1 o'clock	2 o'clock	1 o'clock	2 o'clock	1 o'clock	2 o'clock
a	39.3	39.3	38.3	37.7	42.5	43.6
b	34.9	34.2	33.0	34.7	38.0	37.3
c	35.3	35.0	34.8	34.7	35.7	35.9
d	27.7	28.3	28.2	28.6	26.9	27.4
e	28.3	30.2	29.0	30.7	26.6	28.7
f	33.8	33.4	34.2	33.5	32.7	23.0
g	34.5	33.8	34.6	33.7	34.4	34.1
h	34.0	33.0	34.1	33.1	33.8	32.7
i	33.2	32.8	33.2	32.8	33.2	32.8
j	31.7	32.5	31.2	32.1	32.9	33.6

* 1 and 2 o'clock = 1 and 2 pm.
** Note that the table shows a time gap from 29/6/37 to 12/7/37 between columns 2 and 3.

Table 5.7. Average temperatures at 1 and 2 o'clock.

The site without shadow a has the highest mean temperature all year round, then follows the alternately shadowed site b during the dry season. The lowest temperatures were found at the continuously shadowed sites e and f. The soil c, with rice planting alternating with Crotalaria, has slightly higher temperatures than the water sites; the temperatures among these latter [sites] differ rather little.

As to the permanently shadow-free site a it can yet be mentioned that the soil temperature in the daytime usually varies around the 40 °C between about 10 o'clock [am] and about 4 o'clock [pm].

From the above it follows very clearly that the circumstances, as can be found at a in the dry season also at b and that correspond with those of the soils prepared for tobacco, must be considered lethal tot the tobacco-*Phytophthora*. On the permanently shadowed sites, however, the conditions are favourable to the fungus, so that it may be expected that she can be found here all year round.

In the rice fields and in the conducts the temperatures stay also below the temperature of 37 °C taken by Toxopeus to be critical for the djeroek-*Phytophthora*, but here other factors affect the fungus adversely, namely the activity of bacteria and protozoa, about which more detailed data were communicated in Comm. P.V.T. No. 74 (17). The sudden temperature decreases observed in the soil and in the water (table 5.6) were caused by the onset of the rains. Following the [matter] treated before it will be clear that they will stimulate the release of the zoöspores and therewith will enhance the opportunities for dispersal of the fungus.

The effect of sudden rises in temperature on the release of zoöspores was not studied further. With the high temperatures it is, however, to be expected that they will have no effect; Toxopeus observed the formation of zoöspores with the Citrus-*Phytophthora* by temperature increases at base-temperatures below 15 °C; at higher start-temperatures (checked until 24 °C) this release of spores failed to occur.

For the study of the spread of soil infections it thus matters only to pay attention to the additions of water, either by irrigation or by rains, and the corresponding temperature drops.

As recorded before (17) the wet rice cultivation can largely destroy the *Phytophthora* present in the soil. In culture tubes too the *Phytophthora* mycelium can be decomposed rather fast by means of gutter water or water with sawah-silt added.

In a few cases, however, the destruction of the infection is incomplete. An experience on one of the estates was that, in a bunded area at the centre of a sawah, the infection of two campaigns ago remained sharply delineated in the repeated death of the later plantings placed there (communicated by Mr D. Honig), supposedly because the lack of water-movement could hamper the activity of bacteria and protozoa.

More data on the decrease of infection by the rice cultivation are found in the following. A part of a tobacco planting, which had died almost completely at the end of 1934, showed such a heavy soil infection that the flecks on the leaves could no longer be counted with our leaf-method. One part of this infected land was used for sawah-culture and another part for planting Crotalaria, and for the latter the soil had not been irrigated. On 27/8/'35, the *Phytophthora* figures according to our leaf-method were 0, 0, 0 for the rice plots when dry again at the East Monsoon planting, and for the Crotalaria fields, also at an East Monsoon planting, 16, 8 and 131. On the same soils, fallowed after either kind of planting, but now wetted by rains we obtained on 26/11/'35 the following figures, respectively: 9, 3, 1and 69, 28, 148. Hence, both showed important increases of infection following the original strong decrease. These increases had, however, to be attributed to new infections from a tobacco plantation lying higher.

Nevertheless, such soils would be practically freed from *Phytophthora* by intensifying some sawah-cultures or by the desiccation, as usual with a fallow preceding the tobacco. With these sawah-cultures the bunds should be sufficiently heightened so that the soils are well submerged.

Resuming, we may arrive at the following conclusion: in general our tobacco soils will be considered Phytophthora-free after the preceding rice plantings and the intensive tillage just before planting the tobacco. But in addition to this we must now already draw the attention to some exceptions hereof, namely on the places where either the preceding Phytophthora-infections have been so severe that not all infection can be killed by the above mentioned factors, or new infections arrive continuously from elsewhere.

In the paragraph on 'dangerous sites' we will come back to this point.

5.3. The ways of dispersal

According to the foregoing our tobacco-*Phytophthora* can be found in the following media: in the soil, in the water with the silt therein, in the manure, on the tobacco and on some other plant species. Above we already mentioned the infection on djarak-leaves.[10] A detailed study during the tobacco season showed, however, that in practice we do not need to consider the presence of tobacco-*Phytophthora* in other plants present in the field.

The djarak-plants inspected in the borders of the tobacco fields and on the dessa-grounds only very rarely showed a small fleck, that looked like a *Phytophthora*-lesion, whereas *Phytophthora*-species, isolated from other plants (i.a. *Colocasia esculenta* and *Leucas linifolia*), are of no importance to tobacco. Picked djarak-leaves, used as manure for the rice fields, will, however, be discussed below.[11]

5.3.1. In the soils

For a more detailed study of the regularities in the infections of a tobacco plantation we have to check how the fungus spreads over the various soils. Where the tobacco gardens[12] are situated amidst dessa-grounds, official fields (loenggoehs), and other cultivated areas, one has to consider the presence of *Phytophthora* in these complexes.

The infections, that can pass from these complexes to our tobacco plantation could, after all, be considered a priori of very predominant importance if we compare the relatively small surfaces of our tobacco gardens, where we can take our hygienic measures, to the surrounding much larger areas where our measures cannot be taken. After all, the Vorstenlanden tobacco estates annually occupy only ± 8000 bouw land[13] and are situated amidst other large estates of which the sugar[14], the fibre[15] and the hill cultures[16] are the most important objects. If we limit ourselves only to the areas of a tobacco estate and her near surroundings, it strikes us that every year only a small part hereof is managed directly by the estate. Expressed in general figures we may assume that one third of the area implicated is taken up by dessa-grounds, roads and conducts and that two thirds is land available for cultivation.

Of this land about one fifth is official field (loenggoeh) and four fifths estate area, of which yearly only one half is looked after by the estate.

In advance of that which will be discussed later we can state now already, that it appears a posteriori that the hygienic interference with this relatively small part of the total territory has a dominant effect on the health of the tobacco plantation.

A more extensive study on the course of the *Phytophthora*-infestations throughout the year was made on and near a section of one of the estates. This section had to register very high mortality by *Phytophthora* until and including 1935.

The study is limited to the course of the infections in 1. the tobacco areas, 2. the adjoining cane area, as an example of the areas occupied by the other large cultures, 3. on the official fields (loenggoehs), 4. on the dessa-grounds and roads.

Connected to this an investigation was also made into the presence of *Phytophthora* in various conducts and in a river.

During nearly 4 years soil samples were taken monthly at the various sites and analysed with our leaf-method.[17] The water samples were always taken ± 15 days later.

The results are rendered in table 5.8 and shown in fig. 5.2. The figures are averages per sample of the numbers of flecks obtained from the soil samples concerned and of those obtained by the water analyses. Where the number of flecks on a leaf is so large that they can no longer be counted, 100 flecks per leaf were assumed. With the soil samples this happened only by exception, but with the water study this occurred repeatedly. As in each case 16 leaves were used here, a not-to-count number of flecks on all leaves was taken to be 1600 flecks in total.

In case of the soil sampling 80 leaves per sample were used over and again, as usual; however, the overall figures obtained herewith generally remained lower than those of the five times smaller number of leaves applied in the water sampling. We will come back to this point in chapter V [= section 5.5].

The rainfall figures entered in the figure vary from 1 to 120 mm, whereas the numbers of flecks can be derived from the height of the lines concerned, where it must be understood that the full height of a bar means 200 flecks. If the figure obtained by an analysis surpasses the 200, the number is mentioned besides.

5.3.1.1. The tobacco areas

One has to deal here with the two halves (alternations[18]) of an estate, i.e. the one that is planted with tobacco in a given year and the other, which is planted with rice in that year. The next year the two crops change fields.

From the soils, that are planted with tobacco in the even years, monthly samples were taken on 8 places, always the same ones. This was done 43 times in total; 3 times, however, 3, 3 and 7 samples were taken instead of 8. From the other alternation 25 times 6 samples were taken, 14 times 3 samples, 6 times 5 samples, once 2 samples. The areas planted with tobacco in the even years are placed in another row of the figure than those that are planted with tobacco in odd years.

From July to August one can count on the presence of tobacco in the nursery beds; in the large plantation tobacco is on the field from September through December, sometimes with yet another week in January. Usually the next crop is the Crotalaria which is sown under the tobacco in December, after which the rice comes in the ground in February. The rice culture returns with three successive plantings on the same land, except on those parts that cannot be irrigated adequately in the dry season. Here one has two rice harvests in the two rainy periods, with a dry crop in between, such as cassava, kedele or maize.

In April and May the manure[19] will be spread over the fields to be planted with tobacco in that year, after which the soil is tilled to get rid of its acidity. Before the planting No. I the respective fields are flooded in July and before the planting No. II in August. In September the tobacco is planted in the field. When the rains are insufficient the planted crop is flooded too; this usually happens in September for the No. I and in October for the No. II; each time this takes up some 10 days.

From the inspection of table 5.8 and of fig. 5.2 it can be seen immediately that the severest infections in row I are found during the months December 1934 and January 1935 and during December 1936 and in row II during November 1933 and during December 1935 and February 1936 (Box 5.1).[20] So, for every soil most infection is found in the period that it carries a tobacco crop and just after. Usually, tobacco stalks still remain between the then still growing Crotalaria plants. Later the infection level decreases gradually, to vary at or just above zero level until the next tobacco campaign. Once in a while this infection flares up briefly. Thus, we can now observe in the first place the effect of the tobacco crop and the immediate

Box 5.1. Numbers of Phytophthora spots in Table 5.8 and Fig. 5.2.

Table 5.8.

Horizontal -	Dates from 1933 to August 1937		
Vertical -	Soil analysis (*Grondonderzoek*)		
		Row I -	Tobacco in even years
		Row II -	Tobacco in odd years
		Row III -	Other culture area
		Row IV -	Official fields (*loengoeh*)
		Row V -	Dessa grounds (started mid 1935)
	Water analysis (*Wateronderzoek*)		
		Row I -	100 m below a source
		Row II -	Just outside tobacco area
		Row III -	In centre of tobacco area and backwater
		Row IV -	In even years only in tobacco area
		Row V -	Big river
		Row VI -	Subsoil conducts (started Januari. 1936)

Entries are numbers of lesions counted with the renewed bioassay for *Phytophthora nicotianae*. Fig. 5.2 provides a visual representation of these numbers.

Figure 5.2.

Horizontal -	Dates from November 1933 to August 1937		
Vertical -	Top	Precipitation	(*Regenval*)
	Middle	Soil analysis	(*Grondonderzoek*)
	Bottom	Water analysis	(*Wateronderzoek*)

Rows as above in Table 5.8.

With soil and water analysis the maximum bar length represent 200 lesions counted with the renewed bioassay for *Phytophthora nicotianae*. When the number counted exceeds 200, the count is given to the right of the tip of the bar. The figure visualizes correlations between counts of different rows.

aftereffect thereof in the directly following months and in the second place effects of another kind that cause the said flare-ups. These are found in row I in November 1933 and in March, April and May 1936 and in row II in September, October and November 1934, January through May 1935, August, September, October and December 1936, January, February and March 1937 and May and June 1937. In each case these times indicate an infection coming from the alternate fields that are then cropped with tobacco and supposedly also from the manure, since the times of bringing it out correlate with the increased infections according to table 5.8. We will come back to this possible infection from manure. With the soil study,

Tabel VIII.
AANTALLEN PHYTOPHTHORA VLEKKEN
(NUMBERS OF PHYTOPHTHORA SPOTS)

GROND-ONDERZOEK (SOIL RESEARCH)	22-11-'33	30-11-'33	24-12-'33	28-1-'34	2-3-'34	2-4-'34	1-5-'34	1-6-'34	3-7-'34	3-8-'34	2-9-'34	2-10-'34	6-11-'34	2-12-'34	9-1-'35	2-2-'35	4-3-'35	3-4-'35	8-5-'35	1-6-'35	2-7-'35
I Tabak in even jaren. *(Tobacco in even years)*	1.0	17.7	1.5	0.5	0.8	3.1	0.9	1.1	0.8	0.5	3.6	4.2	10.1	264.6	379.1	125.3	38.5	12.0	6.5	1.5	0.5
II Tabak in oneven jaren *(Tobacco in odd years).*	—	66.0	16.3	4.7	12.0	2.0	0.7	2.0	0.3	1.3	6.7	5.7	18.0	0.3	3.0	14.4	13.0	5.5	2.8	0.2	0.6
III Ander cultuur-areaal. *(Other culture area).*	—	0	0	0	0	0	0	0	0	2.0	0	1.0	0	0	58.0	5.0	40.0	74.0	4.0	1.0	3.0
IV Loenggoeh. *(Javanese official fields).*	4.5	10.0	1.0	0	0.5	2.5	1.0	2.5	0	0	10.5	1.5	2.3	141.5	41.5	163.5	151.0	45.0	22.0	0	0
V Dessa erven. *(Dessa grounds).*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

WATER-ONDERZOEK (WATER RESEARCH)	17-12-'33	19-1-'34	18-2-'34	17-3-'34	17-4-'34	17-5-'34	18-6-'34	17-7-'34	20-8-'34	17-9-'34	18-10-'34	17-11-'34	20-12-'34	18-1-'35	16-2-'35	18-3-'35	17-4-'35	18-5-'35	18-6-'35	19-7-'35
I. 100 m. beneden een bron. *(100 m. beneath a source)*	0	0	0	0	0	1.0	0	3.0	0	1.0	78.0	1.0	6.0	8.0	0	0	0	0	12.0	19.0
II. Even buiten tabaksareaal. *(Just outside tobacco area).*	0	1.7	0	2.3	2.7	0.7	6.6	4.3	2.7	8.3	49.5	61.7	21.0	131.0	20.0	2.7	0.7	0	4.0	78.0
III. Midden tabaksareaal en achterwater tabaksvelden. *(Amidst tobacco area and back water tobacco fields).*	505.5	37.5	22.0	10.8	12.6	3.6	20.8	18.8	45.6	25.6	1209.7	701.0	1283.2	1286.2	133.8	11.2	9.6	12.6	12.4	96.0
IV. Alleen in even jaren in tabaksareaal. *(Only in even years tobacco area).*	193.7	4.3	10.3	5.3	2.7	1.3	13.0	4.6	16.7	38.7	73.0	567,2	1074.3	157.0	42.7	12.7	2.7	3.0	7.7	100.7
V. Groote kali. *(Big river).*	1.0	2.0	7.0	0	1.0	0	27.0	0	408.0	4.0	1600	385.0	1600	161.0	68.0	0	1.0	2.0	11.0	0
VI. Ondergrondsche leiding, *(Underground aqueduct).*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 5.8. Numbers of Phytophthora spots through time. For explanation see Box 5.1.

the effects of the flooding can be made probable only in a single case; this will be shown to be absolutely certain in the water study.

Of the 46 soil analyses in row I a positive reaction was found 43 times, varying from 0.1 to 379.1 flecks per 80 leaves; of those in row II infection was also found 43 out of 46 times, varying here from 0.1 to 249.5 times. Samples completely *Phytophthora*-free or with less than 1 fleck were in row I: 14 times and in row II: 10 times. In the tobacco soils studied the *Phytophthora* could apparently be found also outside the tobacco periods, though this was often the case at a very low level only.

2-8-'35	13-8-'35	29-8-'35	3-9-'35	28-9-'35	5-11-'35	6-12-'35	17-12-'35	31-12-'35	3-2-'36	2-3-'36	3-4-'36	8-5-'36	4-6-'36	25-6-'36	3-8-'36	2-9-'36	5-10-'36	3-11-'36	3-12-'36	5-1-'37	2-2-'37	2-3-'37	7-4-'37	14-5-'37	11-6-'37	2-7-'37	6-8-'37
0.2	—	—	0	0.1	0.3	0.4	—	0	0.6	4.5	3.2	7.8	1.4	0.4	1.8	2.2	1.7	1.0	154.0	12.0	44.7	2.2	3.6	40.6	1.1	1.0	0
0.3	0	0	—	11.1	0.6	27.0	—	114.7	249.5	42.8	32.8	4.2	2.7	0.5	23.0	7.3	8.7	1.5	9.5	5.3	23.1	8.3	1.1	8.8	3.1	11.1	0
0	—	—	0	0	0	1.0	—	0	0	0	15.0	2.0	12.0	2.0	0	4.0	70.0	8.0	9.0	2.0	5.0	1.0	1.0	1.0	0	0	0
0	—	—	2.0	25.5	1.0	47.5	—	2.0	0.5	26.0	6.0	1.5	0	0	1.5	1.0	0.5	3.0	2.0	3.5	6.0	0.5	1.5	6.0	0	0	0
—	0	—	—	—	1.3	29.0	93.3	4.0	68.0	47.5	21.5	16.2	1.8	1.8	0.3	2.0	0.5	2.8	94.0	5.0	9.2	3.7	1.2	14.0	1.0	0.8	0

17-8-'35	18-9-'35	17-10-'35	18-11-'35	17-12-'35	16-1-'36	15-2-'36	16-3-'36	17-4-'36	20-5-'36	15-6-'36	14-7-'36	18-8-'36	15-9-'36	14-10-'36	20-11-'36	18-12-'36	15-1-'37	18-2-'37	16-3-'37	20-4-'37	27-4-'37	24-5-'37	18-6-'37	18-7-'37
0	2.0	0	3.0	0	2.0	0	0	4.0	7.0	4.0	0	—	77.0	116.0	1.0	3.0	2.0	1.0	0	2.0	2.0	0	0	3.0
12.3	10.3	6.0	14.7	2.0	23.7	1.0	0.7	10.0	4.3	2.7	0.7	66.5	93.3	246.0	36.3	3.7	15.0	7.0	0	4.3	7.6	4.0	1.0	2.0
21.4	424.5	139.0	28.0	468.2	1600	608.8	40.0	55.8	31.5	21.8	3.5	27.0	929.5	504.5	230.5	1600	1600	39.0	2.5	24.2	23.8	36.0	3.5	7.7
9.3	17.7	1.7	11.0	11.3	20.3	9.7	4.7	37.4	4.3	4.3	0	12.0	562.3	207.0	352.7	99.3	1068.3	18.0	0.3	3.0	13.6	12.3	1.6	3.0
0	19.0	1.0	19.0	6.0	16.0	7.0	13.0	53.0	25.0	26.0	11.0	49.0	418.0	783.0	57.0	1600	205.0	19.0	0	13.0	14.0	2.0	1.0	7.0
—	—	—	—	—	—	187.0	1.5	0.5	0	0.5	4.0	—	2.0	7.0	466.0	92.0	221.0	1.0	0	2.5	0.5	16.5	0	0

5.3.1.2. Other cropping areas

Of the areas occupied by other crops we repeatedly took samples in a cane garden.[21] The site concerned is chosen so that it is situated near to the tobacco grounds studied, receives water from the same source, but cannot receive waste water from the tobacco areas. Relative to these the site lies slightly higher, being separated from the tobacco area by a broad road and a deep river. The aim of this study is to get an impression of the degree of infections which may survive in the near surroundings and of the extent of infection dispersal outwards along other ways than waste water. During the investigation the crops were rice from November

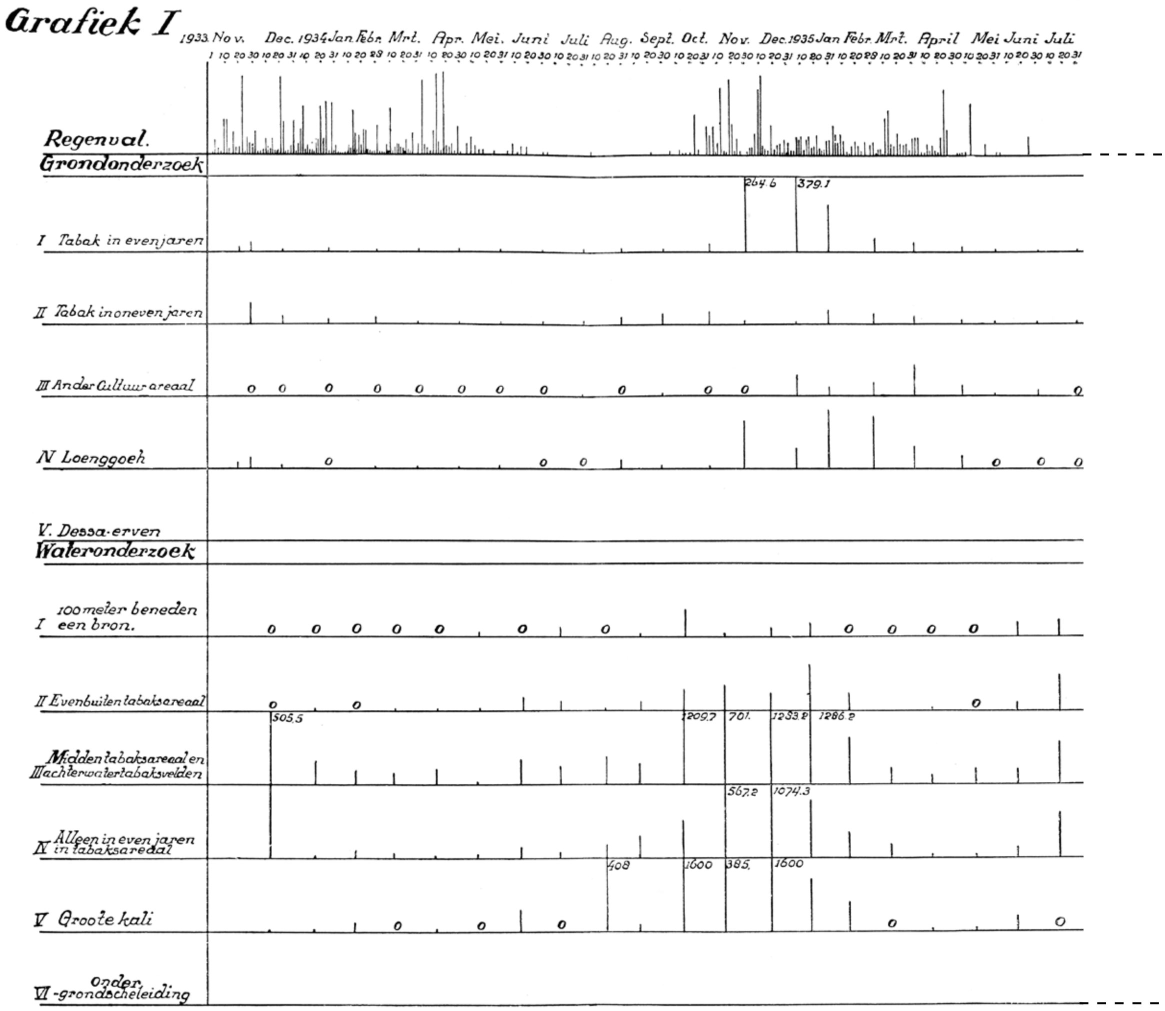
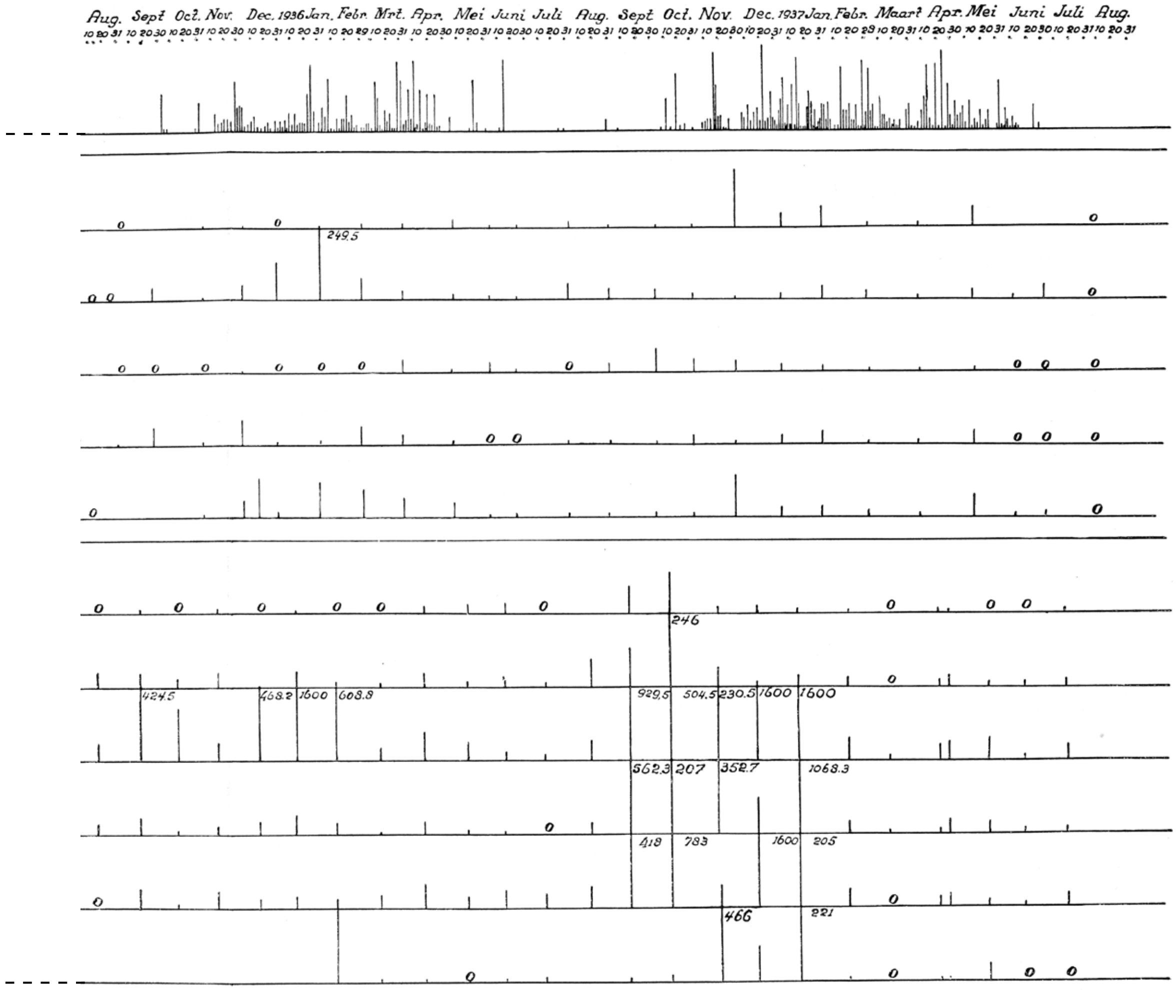


Fig. 5.2. Precipitation and numbers of Phytophthora spots through time. For explanation see Box 5.1.

1933 to April 1934; in May and June 1934 came the tillage; from July 1934 to July 1935 cane, from August 1935 to August 1936 kedele, rice and peanuts, and from September 1936 to July 1937 cane was planted again; after which the field was fallowed for a short time. Each time before the cane planting the field was flooded. Row 3 shows the results of the study. Two peaks of infection are seen here, i.e. in January through April 1935 and in October through December 1936, both during the cane period. In addition an increased infection was found in April through June 1936, during the peanut cropping. Of the 45 times, that samples were taken, 22 indicated no infection. Hence, the probability is high that this soil normally is practically free from *Phytophthora*, but that by way of man or animal infections repeatedly come over from nearby tobacco fields; after all the 3 upsurges



of infection correspond either with the peaks of infection in the tobacco fields or with those in the water just below the source from which the cane garden is irrigated. Row I of the water study shows the infections of this water.

One of the points of difference between this field and the fields planted with tobacco is that it never receives farmyard manure. The not-being-planted with tobacco as well as the not-being-fertilized with manure, which may carry infection, make it probable also that, in the field studied, the occurring *Phytophthora*-explosions are secondary infections coming from the tobacco fields.

5.3.1.3. The official fields

As mentioned before, fields (so-called loenggoehs) have been reserved for the local authorities, which occupy about one fifth of the arable land, whereas four fifths belong to the estate's area. The loenggoeh in case neighbours a tobacco barn and an estate road. In total 46 samples were taken at 2 sites, always the same ones.

From November 1933 through April 1934 the crop was rice, after which the field remained fallow until July 1934. From August 1934 through November 1934 the whole field was planted with Javanese tobacco; in December the field remained fallow and from January through April 1935 it was planted with rice and onions. In May and June 1935 rice beds came here and part of the field remained fallow. A small part, that was under tobacco already the preceding year, was planted again with tobacco from July through December 1935. From December 1935 through September 1936 the whole was planted twice with rice. In October through December 1936 one part had a maize crop and the remainder was fallowed, after which the whole terrain had two crops of rice again up to the end of the study.

The number of times that the examined soil happened to contain no infections was 11 out of the 46 times and that the infections remained below the 1 fleck: 4 times; that is 15 times in total no or weak infection. In general the infection level showed to be lower than that of the tobacco grounds studied.

The explanation probably lies in the fact that the tobacco crop on this loenggoeh grew mainly in the dry season. On a small piece only tobacco was also grown in the rainy season even shortly after the preceding tobacco crop; there the soil then happened to contain a not unimportant infection. The explosion of infection in December 1934 through January 1935 will have originated from the remnants of the native tobacco[22] present just before as well as from the surrounding estate tobacco, since this loenggoeh – as stated already – lies along an estate road and near to a barn, so that the labourers have always to pass along. The heavy infection in February and March 1936, however, must be attributed quite probably to the application of manure. Investigation namely showed that this piece of land had received manure coming from dessa-grounds before the tobacco and before the onion planting. As this manure had not been heated in advance, the probability is very high that she contained infection. These manurings may also be the explanation of the increased infection in the months November 1933, January 1934, June 1934, and September 1935.

5.3.1.4. The dessa-grounds and roads

Only in the second half of the investigation they were sampled, 24 times in total at 3 to 6 sites per case. These sites were dry from August through November 1935, they were wet in December 1935 through February 1936, dry in March 1936 and wet again in April through June 1936. In July 1936 through October 1936 they were dry, in November through July 1937 wet and in August 1937 dry again.

The results of the study of these sites without crop are the following;

Among the 24 times only 2 times no infection was found, in each case in the middle of the dry season (August). Otherwise, the soil always showed to be infected; the peaks of this infection corresponded to those of the tobacco areas.

Manure, collected from these yards, thus has a very great likelihood to harbour infections.

So, the foregoing makes it clear:

When a *Phytophthora*-explosion occurs everything has to be brought into action to localize it. Furthermore, the increase figures of the *Phytophthora*-attacks on the various estates show that the first cases determine the amount of *Phytophthora*-mortality later in the campaign. Some figures can illustrate this:

Section A:	27 Oct:	1008 lanasd. pl.	: 1 Dec:	11312 lanas plants
" B:	27 Oct:	433 lanasd. pl.	: 1 Dec:	7805 lanas plants
" C:	27 Oct:	558 lanasd. pl.	: 1 Dec:	9435 lanas plants

The following figures come from another estate:

Section A:	20 Oct:	11711 lanasd. pl.	: 22 Nov:	34906 lanas plants
" B:	20 Oct:	6094 lanasd. pl.	: 22 Nov:	21010 lanas plants
" C:	20 Oct:	7279 lanasd. pl.	: 22 Nov:	27780 lanas plants
" D:	20 Oct:	3974 lanasd. pl.	: 22 Nov:	12917 lanas plants

The more *Phytophthora*-infections there are in the beginning, the higher the mortality will be later.

Though it does not always hold as good as with the data presented here we can, nonetheless, conclude that we have to be very strict in controlling the first cases of disease.

The final conclusion of the soil analysis is: In the field it turns out that the Phytophthora vegetates to a low extent only in the soils suitable thereto. In dry soils the floodings and the rains can stimulate the fungal parts present there to grow but apparently this growth in general is only weak; an important explosive increase can occur exclusively on the tobacco plant. The first cases of disease lead to an epidemic occurrence on the whole crop when control is not adequate. Then, the infections spread from the diseased tobacco areas over the whole environment, which becomes the more infected the more the crop is diseased. The investigation shows moreover the probability that in the region studied infections even now arrive occasionally in the fields to be planted with tobacco by way of the manure.[24]

5.3.1.5. The dangerous sites in the tobacco area

To this end the rice nursery beds must be taken into account in the first place. These so-called 'widjinans' are a source of infection because they are usually manured with unheated dessa-refuse, djarak-leaves or rests of tobacco from Javanese fields (tops, leaves, etc.).

The tobacco plants grown in the locations, where these nursery beds had been, thus always show a high percentage of mortality. The data collected in one of the estates, where the locations of the preceding rice nursery beds were mapped, prove this correlation of field infection and locations mentioned above. This is mainly serious in the case of the so-called 'consent' rice beds, i.e. those that are used to provide the tobacco fields just fallen vacant with rice plants. [25] In December these beds are placed on the alternation, that will be planted with tobacco within a few months. When the rice plantlets have been pulled up from the beds in January, these locations further remain uncultivated until the tobacco-time. Usually they are moderately moist and not or not fully submerged, so that the manure applied before forms a good nutrient medium for the fungus.[26]

Since in most estates these beds are distributed rather irregularly over the field, it will be of importance to take such measures that from now on they are located in a designated strip, one behind the other. This is already necessary in view of the economical use of the required water. The strips in question can be recorded on maps and be planted with our resistant Timor-Vorstenlanden [variety].

Moreover, inlets and the soils under the barns must be pointed out as dangerous sites; this was already discussed in detail in Communication P.V.T. No. 74. The infection, which has spread from the barn-soils over the plantation is, however, not limited exclusively to the adjacent fields. One can observe repeatedly that during the rainy season covered barns or [barns] destroyed by fire can cause infections to emerge in rather distant places, as usually can be concluded from the course of the soil flushed away from these barns.

The danger of the aforesaid sites is illustrated by the following data, collected in 1936 on one of the estates.

Places	Surfaces In bouws	Number planted plants	Number Phytophthora-diseased plants	% of diseased plants per bouw	Diseased plants counted as % of total diseased plants
Around barns	6.224	94775	35715	37.68 %	10.03 %
Around barns and on places of old rice seedling beds	2.425	41895	15188	36.25 %	4.27 %
Before rice beds[27]	1.075	16907	6462	38.22 %	1.81 %
Around barns and at points of water entry	1.227	21371	9575	44.80 %	2.69 %
Points of water entry	1.006	14880	9968	66.98 %	2.79 %
Total	12.457	189828	76908	40.51 %	21.61 %

Table 5.9. Phytophthora-diseased plants on dangerous places.

On an area of only 12.457 bouws (2.21 % of the planted area) one thus finds no less than 21.61 % of the total mortality of the estate.[28] The estate in case has clearly marked these dangerous sites on maps and has applied a Timor-Vorstenlanden planting on other similar sites. On 3.305 bouws (53,065 plants in total[29]), which is 0.59% of the planted area, only 468 *Phytophthora*-diseased plants were found in the plots planted with Timor-Vorstenlanden, which is 0.13 % of the total estate mortality.[30]

Death rates of plants	1[st] estate (13 Nov.)	2[nd] estate (15 Nov.)	3[rd] estate (30 Nov.)
North section, highest	0.8 %	0.3 %	2.6 %
Middle section	1.2 %	} 0.9 %	2.9 %
South section, lowest	4.0 %		5.5 %

Table 5.10. Influence of the situation of the plantation on the death rates.[a]

5.3.2. In the water

Looking broadly, we may immediately conclude from the available data that the level of infection is highest at the lowest sites. This is true not only with regard to the disease distribution garden by garden, but also to that over a whole estate.

In the first half of November it is clearest that the disease is most frequent in the lowest sections. Later, the effects of heavy rains and of storms may confound the numerical data. Table 5.10 shows the effect of the situation, taken down in one of the preceding years on 3 estates.

This points to a dispersal of infection in the direction of the slope of the terrain; therewith a water-borne infection is probable. By the way, d'Angremond & Honig (2) already pointed to the great role that water plays in dispersing *Phytophthora*-infections. The parts of the fungus present in the silt go with the water and are deposited most in the lower parts.

5.3.2.1. The irrigation water

The correlation between the irrigation of the plantation (the so-called nanglebben) and the appearance of diseases in estate A can be found in the fact that the gardens irrigated first had *Phytophthora* earlier than those flooded later. Besides being spreader of the fungus the water also functions as a stimulant to activate the inoculum. In this context we refer to the paragraphs on the revival of the mycelium weakened by drying out and the swarming of the zoöspores when the sporangia come in touch with water.

On one of the estates the Manager had set up a systematic study looking in more detail at the effect of irrigation water on the level of infection. On the map of the waterways for the irrigations the following classification was made:

I. Areas that receive first-hand irrigation water. Under this designation the water is understood coming directly from springs or from areas never planted with tobacco.

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a Besides lanas-attacks cases of slime disease are also incorporated in these figures; but the latter were largely a minority except on the first estate. Here, in the middle section ± 10 % of the dead plants and in the south section ± 50 % had to be ascribed to slime disease. However, the effect of the situation on the *Phytophthora*-mortality reported above is valid here too.

II. Areas that receive used water from their own alternation. Such water arrives at the tobacco areas concerned after having passed other tobacco areas as sprinkling or irrigation water. The influences operating in the tobacco period proper will be of great importance to the infection level of the water in these areas.

III. Areas that receive used water from the other alternation. This water has been used to irrigate rice on fields which carried tobacco in the foregoing year and of which the effluent water then served to irrigate the rice crop preceding the tobacco in this alternation.

IV Areas that received both kinds of used water.

The following percentages of *Phytophthora*-diseased plants were found in the various areas.

		1935	1936
Section A	I	7.65 %	4.74 %
	II	15.04	4.04
	III	9.35	4.40
	IV	10.78	6.63
Section B	I	3.63 %	2.29 %
	II	8.13	2.60
	III	2.01	4.27
	IV	absent	4.61
Section C	I	6.41 %	3.37 %
	II	16.18	8.32
	III	9.65	9.72
	IV	10.12	10.41
Whole estate	I	5.90 %	3.60 %
	II	10.61	3.92
	III	7.56	5.58
	IV	10.60	6.77

Table 5.11. Disseminaton of Phytophthora-death-rates ranged according the different areas; counted after the harvest of the midleaves.

The foregoing figures lead to the conclusion that the water picks up infections from the areas through which it flowed and that it deposits the accumulated infection on the complexes where it is used as sprinkling or irrigation water.

Indications are thus to be found here for the sanitation of *Phytophthora*-diseased fields.

1). With regard to the used water from the own alternation (Areas II): Take care that the irrigation water has not irrigated tobacco fields before it is used in a particular garden. The conducts should be laid out then in such a way that each garden is treated separately and that the most diseased gardens, situated lowest, are the first to be provided with water.

2). With regard to the used water from the other alternation (Areas III): At the end of the tobacco campaign attention must be drawn to this water; at stake is here the water that flows over the fields with remnants of tobacco and is let into the rice fields where tobacco follows the now standing rice crop. The sawah-crop then lasts but 3 months. In the final month the fields are kept dry during the ripening of the rice. The disinfection-capacity of the wet rice-culture, discussed in more detail in Comm. 74, then has only little effect.[31]

For a long time already it is customary to close the outlets of the tobacco fields before and during the pulling up of the tobacco stalks so that during the most dangerous period the infected water cannot get to the fields destined for the next planting.[32] Besides, it is recommended for lanas-diseased fields to channel the eventually yet free-coming water so that it does not get to areas soon to be planted with tobacco. This must also be prevented in the period that the 1st rice crop (so-called 'consent-paddy') is planted in the fields just left by tobacco.

Furthermore it would be desirable, if feasible, to design the irrigation system in such a way that a mixed irrigation is avoided, that is an irrigation for 2 alternations from one conduct, where the same conduct is thus both supply and discharge conduct.

5.3.2.2. The water in rivers and conducts

The water study on one of the estates took place – as mentioned above – every month; the sites in case were the following;

I. at 100 m. distance below a source,
II. at some water sites just outside the tobacco area;
III. at some water sites in the middle of the tobacco area and in the backwater of tobacco fields;
IV. at some water sites which belong to the tobacco area in the even years only;
V. in a large river;
VI. in an underground bandjir-conduct, which receives water from the river during floods only, and for the rest only contains water seeping from the fields or trickling through.

The results are entered into the second [lower] half of Fig. 5.2.

First, it strikes that the various rows here correlate better among each other than those of the soil analysis. In all 6 water rows the periodical peaks are located in the same spaces of time periods, which points to similar causes of infection. Without doubt the water infection is a secondary infection; the primary medium for the fungus is the soil, from where the infections get into the water. Herein, however, the fungus cannot maintain itself for long, either because she is destroyed or because she is flushed away. This can be established from the fact that each year, immediately following the severe infections during the tobacco time, the infection level becomes minimal again in February. First of all the rains flush the infections present in the soils into the rivers and conducts; furthermore the field workers, the draught animals and the equipment play an important part herein. Even just below a source infections can be demonstrated because this site is the bathing and washing site of men, animals and tools. Finally the drainages from the flooding of the soils cause important water infections. This occurs at the estate in question – as was reported before – regularly before the transplanting, i.e. before the [planting] No. I in July and before the No. II in August and, if the rains are not coming out sufficiently, also later, for the No. I mostly in September and for the No. II mostly in October. To this end about 10 days per case are taken up in the various months; the infections flushed into the water by this treatment of the soils can be recognized in the rows to a greater or smaller degree.

Circumstances such as the water sampling taking place just after a rain shower or during the flooding or during the cleaning of water works and conducts, by which silt is stirred up, affect the higher or lower number of the infections found, so that the figures cannot be considered absolute values.

The heaviest water infections occur mostly at the end of the tobacco campaign (December and January), what can be ascribed to wash-outs by heavy rains during the pulling up of the stalks.

Among the 44 times, that the water near the source was tested [row I], with 16 leaves each time, it was found infected 24 times. The numbers found here varied from 1 to 116.

The testing of the water sites outside the tobacco area [row II] was done each time at 3 sites (with 3 exceptions, at 2 sites); *Phytophthora* was found 41 out of 45 times; the infections varied on average from 0.7 to 246 flecks per batch of 16 leaves. Though the water sites here, as the one near the source, are situated higher than the tobacco areas studied their water may nonetheless get infections – as stated above – by way of field workers and animals, and at 1 water site of this study also from the cane garden studied above.

In the midst of the tobacco area and in the backwater of tobacco fields 4 to 6 water sites were sampled each time [row III]; all 46 times showed infections, varying from 2.5 to 1600 flecks per 16 leaves. During the tobacco months the infection levels are very high but [they] decrease sharply in the period beyond, though without becoming entirely *Phytophthora*-free.

The analysis of the water from areas, that are planted with tobacco in the even years only, provides a confirmation of the preceding; only in the period of tobacco cropping severe infections were found in this water; in the odd years the infections were – also in the dangerous months December and January – about equal to those of row IV, i.e. of the areas outside the tobacco fields. Here always 3 points were sampled (by way of exception once 1 point and once 2 points); 44 times out of 45 dates infections were found varying from 0.3 to 1074.3 flecks per 16 leaves.

In the big river [row V] the water was sampled 46 times always at the same site; infection was found 39 times, varying from 1 to 1600 flecks per 16 leaves. The heaviest infections were found during the tobacco seasons of the even years, which is no surprise since only the tobacco fields of these years drain off toward this river.

Finally the water of the foresaid underground bandjir conduct [row VI] was sampled at two sites each time; it was found to be infected 14 out of 18 times; the figures ran from 0.5 to 466 per 16 leaves. Here the infection is to be attributed to silt originating from the foresaid river and from fields that can discharge water into this conduct through breaches. Here too a similar course of infection was found. The additional remark has to be made that water, extracted exclusively underground, is in itself *Phytophthora*-free, as was shown at another estate. Here a soil water wellhead is struck in which exclusively water from deep-lying layers is drawn. A sampling in December at 6 sites, situated underneath tobacco fields, gave a negative result though *Phytophthora*-diseased plants could be found in the plantation here and there.

Summarizing we may state: heavy water infections are to be feared only during the tobacco season. The heavier the infection of the tobacco fields is, the more the water, that is in contact therewith, becomes infected and the greater the probability of infection of the whole environment. The infections of this water beyond the tobacco season and of the water, that has no direct contact with tobacco fields during the tobacco season, can be called weak. The degree of infection is further discussed in chapter V.

The strong decreases of the water infections after the tobacco season, probably due to the activity of bacteria and protozoa, are quite conspicuous.

5.3.3. In the manure

The manure samples submitted every year to the Experiment Station showed already a never to neglect percentage of infections with the rather insensitive method of analysis. In 1935 we found 52 % of the manure samples tested to be infected, in 1936, 45 % and in 1937, 13 %. Though we can thus see a tendency toward improvement, the fact of manure infection being present, as well as the distribution pattern of the *Phytophthora* in the plantation that can be observed here and there, has given us the impression, that important parts of the *Phytophthora*-infections in our Vorstenlanden estates still get into the planting area by way of the manure. The soil and water studies mentioned previously have strengthened this impression.

Since the foregoing also shows that nearly all year round more or less heavy infections can be demonstrated at the dessa-grounds and at the roads, it is no wonder that the manure obtained from the dessa's carries infectants. The great merit of d'Angremond has been to have elaborated a good disinfection method, first with carbon disulphide and later by the application of manure heating. Not everywhere, however, the heating appears to be applied effectively, or are later re-infections prevented.

That the pattern of disease distribution may make infection by way of manure likely, we can explain by the following example: On one of the estates the fields were fertilized with manure, those near 5 barns excepted. These 5 barn areas, situated in the centre of the estate, received Crotalaria exclusively. On 13 November, the dead plants of these 5 places amounted to 0.61 %, 0.66 %, 0.74 %, 0.59 % and 0.44 %, on average 0.61%, while at the same date the mortality rate of the entire estate was 2.0 %. In this last figure, however, the highest disease percentages were also incorporated, i.e. of gardens which had slime disease besides *Phytophthora*, as well as the lowest disease percentages, those of the Crotalaria plots. If we eliminate these highest and lowest mortality data then we find for the remainder of the estate an average of 1.32 % which is more than twice the percentage of plants killed by *Phytophthora* in the Crotalaria areas.

The date of 13 November was chosen here because until and including that date the *Phytophthora*-figures showed a gradual increase over the whole estate and thereafter suddenly increased very strongly. This sudden increase is to be attributed to the bad weather that raged on 10 November when serious storm damage was registered. After 13 November the consequences of these damaging factors came through. From this date onwards the month of November was characterized by continuous rains for the estate concerned. After 11 November *Phytophthora*-flecks began to appear on the leaves which on 13 November expanded to infections of the stems. The said continuous rains not only made it difficult to remove the leaves with *Phytophthora*-flecks, but also furthered the infection by the lanas-spores which dripped down from these leaves with the water.

The fact that the presence of leaf flecks occurred already on 11 November to such a degree points to a heavy soil infection prevalent on this estate. This general infection provides another demonstration that the applied manure was infected. After all one can assume in general – as already explained above – that the soil is largely *Phytophthora*-free after 2 to 3 times rice paddy and the subsequent intensive tillage operations.

In view of the preceding it is our conviction that a considerable part of the *Phytophthora*-mortality now still occurring can be eliminated by executing the manure-disinfection as sharply as possible and by making the check of the manure as severe as possible. A more sensitive *Phytophthora*-method will serve this purpose; in the next chapter such a method will be discussed in detail. Now the possibilities must be worked out to perfection the manure-disinfection by means of piling up.

To obtain *Phytophthora*-free manure the following conditions must be observed:

1st. good quality. The manure has to be as fresh and pure as possible. It is worth the effort to keep strictly to this requirement when purchasing. Old, fermented manure or manure mixed with soil is difficult to bring to heating. To be sure it is possible to enforce heating by mixing with fresh organic material, as with green or with still strongly heating tobacco parts or with wet straw, but the mixing needed hereto has to be strictly supervised in order to ensure that all layers are well mixed.

Under good quality is also meant an appropriate humidity level; too dry or too wet manure does not heat sufficiently.

2nd. right time of purchasing. Only the East Monsoon lends itself to the acquisition of manure. Much damage is suffered by the purchase of manure in the rainy season. Not only time is then too short for correct heating in view of the carting out in the months April and May but also the mass, if too wet, does not attain the desired temperature anymore. In addition, the infection level of the dessas is highest in this period so that the probability of manure-infection by the collection and transportation then is highest.

3rd. right place to pile up and adequate size of the piles. Only a single estate has the opportunity to use ideal locations hereto, namely covered spaces built in brick, such as former indigo barns.

Where these are not available or where high transportation costs make such centralization of manure heating inadvisable, one has to pile up the manure in the drying barns or on rented dessa-grounds.

Due to the extensive studies of d'Angremond as well as to our own observations we can state with certainty that the greater part of the barn and dessa soils is infected, especially when they are moist. Herewith a stiff disinfection of the necessary soils is imperative. This may be done effectively and in a rather simple way by lavish watering with 1½ % copper sulphate. Moreover, storage sites in the open field must be well chosen and diked in so that during the rainy season the manure is not soaked by water that flowed over the dessa grounds. Also the manure has to be protected effectively against rains.

When piling up in barns one is forced to build one pile in multiple chambers in order to obtain the necessary size of the piles, as a result of which the posts are enclosed; these then must be protected against decay. In addition measures have to be taken in such a way that these manure piles do not cause hindrance at harvest time or get infected again.

4th. a good treatment. First of all it has to be checked whether the heating reaches a satisfactory level. The experience has taught that 60 °C at about ¾ m from the outsides of the pile can be adopted as a criterion of good manure heating. It is true that lower temperatures, especially during prolonged exposure, can kill *Phytophthora* too, but temperatures of 60 °C or more are desirable to reach all layers in the pile satisfactorily. One should not go too high because of the risk of self-ignition. Temperatures over 80 °C are becoming dangerous.

The outer layers do not get sufficient heating and it is preferable not to use them up to ± 30 cm thick, unless the pile can be turned over, observing the necessary hygienic precautions, so that the outer layers come inside and can be heated too.

During the carting out care has to be taken to avoid re-infection of the manure by e.g. measuring it out on infected soil in barns or on the roads. It would be best to cart the disinfected manure out as hot as possible, from the piles directly to the areas to be manured.

Finally it be stipulated that – whenever possible – manuring with Crotalaria is preferable from a hygienic point of view. Sowing it under tobacco toward the end of the campaign, cutting thereafter, piling up on disinfected barn soils, and carting out onto the other alternation or sowing it on the alternation to be planted and ploughing under immediately thereafter offer lower risks of infection.

The processing of seed bolls and young green parts of tobacco remnants to usable manure were already discussed extensively in Comm. P.V.T. No. 74.[33]

5.4. A new Phytophthora-analysis-method

In Communication P.V.T. No. 74 the method of *Phytophthora*-assessment in soil and manure samples by means of tobacco leaves was discussed, in which the low sensitivity of the method was pointed out; with rather important infections too few flecks often appear on the leaves used or none at all. In the foregoing it was already brought forward that with the use of old leaves the number of flecks of the assay can be much larger than with the use of strongly growing leaves, while in general this number is also considerably higher with the water analysis than that obtained with the soil samples at roughly corresponding dates, notwithstanding the use of 5 times lower number of leaves (see fig. 5.2).

As a result of these observations it was tried to find a more sensitive method than the usual one. The introduction of old leaves instead of strongly growing ones immediately caused difficulties in connection with the rapid rotting; that's why the attention was directed towards the water assay. Moreover, this is also important for the investigation of the meaning of the number of flecks found with the soil samples as compared to those found with the water analysis. Hence, the question became whether it would be possible to analyse the soil and manure samples with the method of the water analysis and whether herewith a larger number of flecks could be obtained. For brevity only that method is reported here that was the most satisfactory of all methods tried.

A series of paraffin tins is put together so that 10 litres of the soil or manure samples to be assayed comes in the first tin. Sketch A [fig. 5.3] clarifies how by influx of tap water from the bottom of this tin and by regular stirring a slow stream of silt is led along the leaves that are located in the other tins. The course of this stream is directed so that the water flows out of the tin**s** with leaves at the underside. In the successive tins less and less silt streams along the leaves due to gradual sedimentation. The most satisfactory of the flow rates studied is the one where a tin with a volume of 20 litres fills up in 15 minutes time and of the flow periods studied the duration of 2 hours.

With higher flow rates and shorter infection times fewer infections appear, whereas with longer infection times the leaves show necrotic lesions.[34] Lower flow rates have not yet been studied.

After the end of the experiment usually only shingle and sand show to have stayed behind in the tin for soil or manure, while in the successive tins with leaves smaller and smaller amounts of silt have settled.

Following the infection the leaves are stored between banana leaves in the same flat tins just as with the old brush method, but now they no longer need to be rinsed after 24 hours, which implies an important economy of labour.[a]

After two times and three times 24 hours the generated *Phytophthora*-flecks are counted. For the experiments mentioned below the soil to be assayed was very well mixed, 10 litres were assayed following the old method and in each case 10 litres in a parallel set of 4 series (A, B, C, D) according to the new method.[35] Every series consisted of 4 tins with 16 leaves each.

With severely infected soils it showed to be necessary to mix these with sterilized soil in order to avoid too large numbers of flecks. In this way it was possible by means of these 'dilutions' of infections to demonstrate the greater sensitivity of the new method; 'dilutions' which showed no flecks with the old method still gave a positive reaction with the new one.

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a	See postscript on page 152.

The data of the experiments I, II, III and IV show that soils, in which no infections could be indicated anymore with the old method, still give a positive *Phytophthora*-reaction according to the new method. Similarly, the experiments V, VI and VII demonstrate the higher sensitivity of the latter method. It also appears, that with every series one tin would have been sufficient; the first tin gives always the highest lanas-figure except for experiment VI series B and experiment VII series A and B; only with the severe lanas-infections of experiments VI and VII a

Soil and method Experiment I; 24/11/37	**Number of leaves**	**Total number of spots**	**Average number of spots per leaf**
Soil undiluted (100 %)			
Old method	32	48	1.5
Soil diluted (0.2 %)			
Old method	80	0	0.0
New method			
Series A tin 1	16	8	0.5
2	16	2	0.1
3	16	1	0.1
4	16	0	0.0
Series B tin 1	16	1	0.1
2	16	1	0.1
3	16	0	0.0
4	16	0	0.0
Series C tin 1	16	4	0.3
2	16	1	0.1
3	16	0	0.0
4	16	0	0.0
Series D tin 1	16	9	0.6
2	16	0	0.0
3	16	1	0.1
4	16	0	0.0

Soil and method Experiment II; 29/11/37	**Number of leaves**	**Total number of spots**	**Average number of spots per leaf**
Soil undiluted (100 %)			
Old method	32	13	0.4
Soil diluted (0.2 %)			
Old method	80	0	0
New method			
Series A tin 1	16	3	0.2
2	16	2	0.1
3	16	0	0.0
4	16	0	0.0
Series B tin 1	16	6	0.4
2	16	3	0.2
3	16	0	0.0
4	16	0	0.0
Series C tin 1	16	4	0.1
2	16	0	0.0
3	16	0	0.0
4	16	0	0.0
Series D tin 1	16	0	0.0
2	16	0	0.0
3	16	0	0.0
4	16	0	0.0

Table 5.12. Numbers of Phytophthora spots according to the old and the new method. Stream flow 20 liter per 15 min.; period of flow 2 hours; spots counted after 3 x 24 hours. (Lay-out of table slightly rearranged).

Soil and method Experiment III; 30/11/37	Number of leaves	Total number of spots	Average number of spots per leaf
Same soil 'diluted' to 0.2 %	32	13	0.4
Old method	80	0	0.0
New method			
Series A tin 1	16	3	0.2
2	16	1	0.1
3	16	0	0.0
4	16	0	0.0
Series B tin 1	16	5	0.3
2	16	0	0.0
3	16	0	0.0
4	16	0	0.0
Series C tin 1	16	4	0.3
2	16	1	0.1
3	16	0	0.0
4	16	0	0.0
Series D tin 1	16	0	0.0
2	16	0	0.0
3	16	0	0.0
4	16	0	0.0

Soil and method Experiment IV; 7/12/37	Number of leaves	Total number of spots	Average number of spots per leaf
Soil diluted to 1 % Old method	80	0	0.0
New method			
Series A tin 1	16	6	0.4
2	16	2	0.1
3	16	0	0.0
4	16	1	0.1
Series B tin 1	16	12	0.8
2	16	4	0.3
3	16	0	0.0
4	16	0	0.0
Series C tin 1	16	10	0.6
2	16	6	0.4
3	16	0	0.0
4	16	0	0.0
Series D tin 1	16	7	0.4
2	16	4	0.3
3	16	1	0.1
4	16	0	0.0

Table 5.12 (continued).

higher infection occurs sometimes in the 2nd tin. With higher flow rates, as with the filling up of a tin in 5 or 10 minutes, this has been seen too.

That the various series of each experiment do not always yield the same figures with corresponding tins, can be attributed to the fact that in spite of very intensive mixing the infections in these tins cannot always be exactly the same and that the flow rates, regulated by means of a valve, cannot always be exactly the same.

In addition we asked ourselves whether with increasing level of infection this should be demonstrated according to the old or according to the new method. Also, the difference in *Phytophthora*-sensitivity between Javanese and plantation tobacco was studied. Heavily infected, well-mixed soil was mixed with sterilized soil in various proportions. The corresponding 'dilutions' were analysed according to both methods. With the water method 3 tins per case were used, in which mostly leaves of Javanese tobacco and occasionally leaves of plantation tobacco were hung. Table 5.13 shows the resulting data.

The data show that the water method is more satisfactory; the figures from the first two tins show every time a clear gradation of infection. Furthermore one sees that the plantation tobacco in the third tins of this method suddenly show larger numbers of infections than the corresponding preceding[36] Javanese tobacco; where otherwise these tins give smaller numbers, it demonstrates the higher susceptibility of the plantation tobacco to *Phytophthora*-infections; this is also apparent from the old method. Because of the high flow rate the numbers of flecks per leaf of the first tins are, at the lower percentages, not substantially higher than the corresponding [ones] from the old method.

With respect to the proportion of the numbers obtained with the soil and water study (graph I [fig.5.2]) we may state now, that with equal infections these are expressed much stronger with the water than with the soil, since herewith the old method had not yet been applied. Furthermore, it is probable that soils, having

Soil mixtures	Old method			New method		
	Number and kind of leaves	Number of spots		Number and kind of leaves	Number of spots	
		Total	Per leaf		Total	Per leaf
1 %	80 Jav. tab.	35	0.4	Tin 1: 16 Jav. tab.	13	0.8
				" 2: 16 Jav. tab.	6	0.4
				" 3: 16 Jav. tab.	5	0.3
2½ %	80 Jav. tab.	46	0.6	Tin 1: 16 Jav. tab.	29	1.8
				" 2: 16 Jav. tab.	15	0.9
				" 3: 16 Jav. tab.	5	0.3
5 %	80 Jav. tab.	73	0.9	Tin 1: 16 Jav. tab.	41	2.6
				" 2: 16 Jav. tab.	31	1.9
				" 3: 16 Jav. tab.	19	1.2
7½ %	80 Jav. tab.	102	1.3	Tin 1: 16 Jav. tab.	86	5.4
				" 2: 16 Jav. tab.	71	4.4
				" 3: 16 Jav. tab.	41	2.6
10%	48 Jav. tab.	62	1.3	Tin 1: 16 Jav. tab.	138	8.6
	32 Pla. tab.	52	1.6	" 2: 16 Jav. tab.	92	5.8
				" 3: 16 Pla. tab.	**136**	**8.5** [37]
12½ %	64 Jav. tab.	75	1.2	Tin 1: 16 Jav. tab.	177	11.1
	16 Pla. tab.	36	2.3	" 2: 16 Jav. tab.	116	7.3
				" 3: 16 Pla. tab.	**171**	**10.7**
25 %	64 Jav. tab.	124	1.9	Tin 1: 16 Jav. tab.	304	19.0
	16 Pla. tab.	28	1.8	" 2: 16 Jav. tab.	217	13.6
				" 3: 16 Pla. tab.	**296**	**18.5**
50%	74 Jav. tab.	157	2.1	Tin 1: 16 Jav. tab.	∞*	∞*
	6 Pla. tab.	33	5.5	" 2: 16 Jav. tab.	334	20.9
				" 3: 16 Pla. tab.	**337**	**21.1**

* A great number of merging spots; not to be counted.

Table 5.13. Numbers of Phytophthora spots got at increasing rates of infection with Javanese and plantation tobacco. Stream flow 20 litres in 6 minutes; time 2 hours; spots counted after 3 x 24 hours.

shown negative reactions with the old brush method, will yet turn out to contain infections according to the new method (that is as silt by way of the water study). Herein we must find the explanation for the fact that every year, according to Fig. 5.2, the water infections seem to appear earlier than the soil infections. That, however, the infections in the water disappear earlier, we can thus take to be real. Once more this demonstrates the disinfection capacity of the water.

To get an impression of the water infection by infected soils with rain showers and with inundation 10 litres of soil, of which the lanas-figure after 2 x 24 hours was 113 and after 3 x 24 hours 227, was led as silt over 5 tins with 16 leaves each. To imitate a good rain the flow rate was taken rather high, in such a way that 220 litres of water was used in 2 hours' time. The figures so obtained after 2 x 24 hours were successively 1492, 1613, 1233, 917 and 753; after 3 x 24 hours they could not be counted anymore. From this it follows that with rains and with the flooding tobacco soils infected to such an extent must cause infections in the conducts lying underneath them which give numbers of flecks that no longer can be counted.

The experiments mentioned above, as well as some 20 other series not published for the sake of brevity, have provided us with the evidence that we possess in the new method a more sensitive and simpler method to assay samples for *Phytophthora*. To analyse a large number of entries we need to build an installation where different samples can be analysed simultaneously. By letting each sample flow over two bins with 16 leaves each, we will get all certainty that with low flow rates and adequate infection periods almost no infections will escape these leaves. The tap water that we use shows to be free of *Phytophthora* in repeated tests with sterilized soil.

Postscript.

After writing the above we have already had the opportunity to apply the new method on a big scale. It is now put into use by the Experiment Station as well as by the estates as follows:

Manure or soil samples are placed in marked tins: each of these tins is placed separately besides a recipient tin (1st tin in sketch A) following transfer of its content to the latter. The stream is led over 16 leaves, threaded to an iron wire bent round and placed in the lower tin. After the 2 hours these leaves, hanging on the iron wire, are transferred to the original, marked sample tin, covered and kept covered for 3 times 24 hours, after which the flecks developed thereupon are counted. In this way mistakes about the origin of the foliar infections are prevented in a simple manner. The possibility that too many flecks would be counted due to mutual infection of leaves touching each other is small because secondary flecks are easily recognized.[38] After some experimentation it came out that in practice 1 flow, that is for every sample only one tin with 16 leaves, is sufficient and also, that seedlings (bibit-plantlets) can be used for want of developed leaves. These then are cut at some distance from the soil and with the stems, carrying 4 to 5 leaves, threaded to the iron wire. In that case care has to be taken that no plantlets are used coming from beds where *Phytophthora* has been found. One of the installations in use is depicted in Fig. 5.3.

In reply to the question what leaves might be used for want of tobacco leaves and of tobacco seedlings, experiments were started with djarak-leaves (*Ricinus communis* L.) in connection to other experiences. These, however, are not exclusively susceptible to the tobacco-*Phytophthora* so that they can also give flecks of other *Phytophthora*-species in infected soil and manure types, which is not the case with tobacco leaves. Besides disadvantages this general susceptibility brings along the advantage that the method becomes much more sensitive; with the heating of manure, after all, one may assume for the *Phytophthora*-species present here that they are killed by 60 °C during one ½ hour. So, if flecks would still be found with djarak-leaves then it would be possible indeed that these do not come from tobacco-*Phytophthora* but they demonstrate nonetheless that the prescribed heating is not yet attained. The numbers of flecks found with various corresponding samples and leaves of nearly equal size are, recalculated per leaf, as follows:

with tobacco leaves	with djarak leaves
0.6	14.4
0.2	7.8
1.1	5.5
7.1	31.6

In this way recourse can be taken to djarak-leaves to assay manure for lack of tobacco leaves. [39] Most appropriate is the djarak-variety which in the Vorstenlanden is known under the name 'djarak kepiar' and more specifically the green variety.

5.5. Concluding remarks

Collecting the necessary data for the present study we asked ourselves several questions that we mentioned already in the introduction. One of these questions was: 'How does the infection enter the tobacco area ?' This, as the question: 'Can measures be taken to ward off the threatening dangers?' we can now also put to an answer by enumerating the measures that will be useful to further sanitate the estates. In the foregoing we already brought forward that in:

a) the manure we have to fear an important infection factor. A strict control by means of our simplified and sharpened method can be practiced on the estates themselves: the piles, which before carting out still show *Phytophthora*-infections, must be declared unfit. To avoid a shortness of manure an ample supply should be stocked during the East Monsoon, whereas the conditions stated for the purchase should be strictly maintained. The conditions for a good disinfection were discussed already.

Furthermore we have to focus our attention on:

b) the fields. When the fields are turned over to the estates they have been, in most cases, under a rice cultivation of 2 or 3 harvests, depending on the possibility to grow rice in the preceding East Monsoon. These fields are usually *Phytophthora*-free but in some cases they can already be infected according to Fig. 5.2. This depends on the plantation hygiene of the preceding months and also on the higher or lower frequency of the danger spots already mentioned before, i.e. former rice beds, barn drains and water inlets.

Besides infection by way of the silt that is deposited by water of the foregoing campaign on the areas soon to be planted, infections from earlier tobacco plantings can be left over on the spot in these areas.

For the operations control the sites indicated as dangerous have to mapped. Often, desiccation of these sites alone is not fully effective because of the heavy infection present shortly before; using the maps these sites can be planted with our resistant Timor-Vorstenlanden [selection]. In addition it be stipulated that no beds may be set out on these sites.[40] *Phytophthora* in the beds is always a serious source of infection in the plantation. Besides the possibility mentioned earlier to position the rice beds in a well-organized strip, it should be attempted to prevent infections herein with dessa-dirt, djarak-leaves, and green tobacco-waste by inducing to apply heated manure or [artificial] fertilizer.[41] The infection from the barns can be reduced to a minimum by good upkeep of the surrounding dikes and conducts. All too often it can be stated even now that in the rainy season the water flows from the roads over the barn grounds and spreads the barn dirt over the area to be planted with tobacco. The covering of the barns at the right time so that these are not open during the rainy season will also counter the spread of infection.

When one begins with infected soils on the complexes to be planted, then the possibility is great that the tobacco plants will become diseased, particularly after the irrigation and after the rains, since water – as explained already before – is a stimulant activating the fungus. In the plants that became diseased the amount of inoculum multiplies very strongly and becomes a source of infection for the surrounding places. At this we have to discuss the role of

c) the water. The difference already stated above between higher and lower situated complexes demonstrates the transportation of disease germs by way of the water. Attached to silt particles, in which they have grown, the *Phytophthora*-infectants become mobile with rains and with irrigations and spread over all the surroundings by way of the labourers, the draught animals, and the implements. The disease situation of a certain garden does not only affect this garden, but also the whole surroundings and specifically the areas lying below.

Of the greatest importance is the suppression of the *Phytophthora*-infection at the onset of the campaign. The lower the *Phytophthora*-figure is in the beginning, the smaller this remains during the campaign. From this it follows that those estates, which at the filling up the diseased places get rather much disease again, should better refrain from filling up, or should exclusively use a resistant variety hereto.

Moreover the role of the water was already amply explained under the discussion of the lay-out in the various irrigation-areas; now we only have to point, perhaps unnecessarily, at the well-known measure to shut down the drains in the period that the tobacco stumps are pulled up; often this simple measure is still left undone. The soil infection of the tobacco areas is greatest during that period, whereas the risk of translocation by the soils coming loose is highest. The heavier the rains are in this period, the more difficult it becomes to keep the soil particles on their original places.

So we can also answer the question: 'To what degree the infection risks of a plantation can be calculated in advance?':

a. The heavier the preceding soil infection has been, the more serious the dangers are for the coming tobacco crop.
b. The heavier the rainfall is at the end of the tobacco campaign, the higher the infection risks are for the coming campaign.

For the estates which during the last months of the campaign sow Crotalaria between the tobacco plants, the following comment be made: The wet rice culture that usually comes on the fields immediately after the pulling up of the stumps, now comes some time later. The disinfecting effect of the wet rice fields thus is shifted. Meanwhile the infection remains at nearly the same level. The stumps can be pulled up only when the Crotalaria has rooted sufficiently. Here, as later with the pulling up of the Crotalaria, one should not forget to shut the drains. Where at all possible it is even recommended to cut the Crotalaria. Besides not pulling loose the soil, one does not carry infected soil particles with the roots to places, where the Crotalaria is piled up and to the areas where it is ploughed under. These soil particles are difficult to disinfect in the piles because soil is a poor heat-conductor. On the estates, where this is feasible, the above mentioned drawbacks could be overcome by the other Crotalaria-method, namely by sowing this on the fields which are given back to the estate by the population , i.e. in the months February and March and to work it under on the spot after ± 1½ month. Until the time of planting on these fields in September one has still sufficient time to apply the necessary tillage [operations].

Now we are left with the question when it is the best time to apply silt to the paddy fields. There is a risk that, simultaneously with this so necessary material, infectants get to the fields too. The water analysis has, however, already shown that the heaviest infections in the rivers and conducts are to be found during the pulling of the stumps and that normally in the month of February and thereafter the infections are minimal until the next tobacco season.

Where we need to have the silt of the floods (bandjirs) and these bandjirs are most frequent and richest in the second half of the West Monsoon, we will – after having closed the inlets during the period of pulling up the tobacco stumps – have the opportunity to silt up practically without risk. In February the locks can also be opened during bandjirs and mainly the so-called 'consent'-paddies will have to be silted up. These are the sawahs which will be tobacco land again only in the next year. As soon as the rice standing there is tall enough not to suffer damage therefrom, the lavish silting up (with sufficient water for disinfection) must take place. On the paddies that will be tobacco lands soon the silting up can come about only briefly, since they must be desiccated soon. Here the disinfection by sufficient water, for which high paddy bunds[42] are recommended, must be well observed. The open exposure of the fields with the associated intensive drying before planting the tobacco must further take care of the total disinfection.

5.6. Summary

The epidemiology of the Phytophthora disease on the Vorstenlanden estates.[43]

A study has been made of the parasitology and the saprophytic life of the *Phytophthora parasitica var. nicotianae*, as well as the manner in which the infection occurs in the Vorstenlanden estates.

The fungus can attack besides tobacco plants also leaves of some other plants as mentioned in table 5.1 and can live in different types of soil (table 5.2) where sporangia are formed.

The liberation of swarmspores happens mostly soon after the sporangia are plunged into water; in some cases a fall of temperature is hereby necessary (table 5.3).[44] The swarmspores cause infections on the underside of the tobacco leaves with difficulty and none at all on the upperside, but easily form new mycelium in soil and on culture media.

Phytophthora in culture tubes dies off by heating at 50 °C. during 1 hour and at 49 °C. during 2 hours as also by desiccation.

Temperatures have been registered in *a*) not tilled and not shaded sandy soil, *b*) in regularly tilled clay soil with occasional shade, *c*) in a field with rice interchanged with Crotalaria during the dry monsoon, *d*) in lowly situated clay soil with continuous shade and *e*) in highly situated clay soil with continuous shade as also in the following places in water, *f*) flowing water with occasional shade, *g*) same without shade, *h*) same with continuous slight shade, *i*) same with continuous dense shade, *j*) stagnant water on a mostly shaded place (tables 5.6 and 5.7).

The conditions of the soils *a* and *b* agree with those of the tilled soils before the planting of the tobacco; the temperature being often very high and the desiccation being very intense our tobacco soils generally can be considered free from *Phytophthora* infection before the planting.

Exceptions to this are the places where former infections have been exceedingly high or where permanently new infections occur. These are areas around barns, old rice seedling beds and points of water entry (table 5.9).

In constantly shaded moist soils the fungus can live throughout the whole year; in the water of the rice fields and in streams the temperature is mostly not too high, but the fungus will be attacked by bacteria and protozoa.

The fall of temperature in soils by rains will help the liberation of swarmspores in the water; these are transported by the water and will spread the infection mostly to the lower areas.

The fluctuations of soil- and waterinfections have been studied during almost 4 years on and around a part of one of our plantations; this part was very diseased up till 1935.

Fig. 5.2 and table 5.8 show the monthly grades of infections. The conclusion about this soil research is, that *Phytophthora* is to be found in suitable soils only to a small extent; an explosional increase can only take place in the tobacco plant.[45] The first diseased plants will give an epidemic infection over the plantation and its surroundings if they are not instantly controlled. The research makes it probable that the manure brought from the villages still often brings infection on the investigated tobacco areas.

The water in rivers and conducts which are in contact with tobacco fields has been found infected especially in high degree in the period when the tobacco is on the fields. In other times this water and the water of areas not being in direct contact with tobacco fields is only slightly or not infected.

A new very sensible method for *Phytophthora* research in soils and in manure is described (Fig. 5.3, 5.4).[46]

In practice the method is employed as follows. Water flowing with a rapidity of 20 litres in 15 minutes transports a suspension of soil or manure over 16 tobacco leaves in a tin. After 2 hours these leaves are brought in another tin and kept moist during 3x24 hours. After this time the *Phytophthora* spots formed give a measure of infection.

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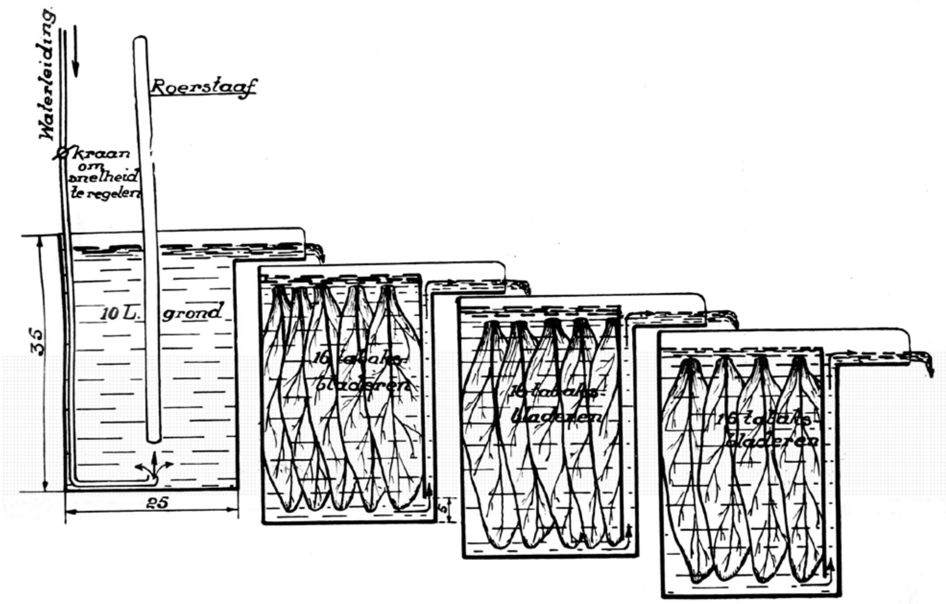

Fig. 5.3. Sketch of the equipment for the bioassay of Phytophthora parasitica var. nicotianae in soil and water.Legend: Waterleiding = *water pipe with kraan = valve.* Roerstaaf = *stirrer.* 10 L grond = *container for 10 litres of soil. Three sub-ordinated containers with 16* tabaksbladeren = *16 tobacco leaves each. Measures in cm.*

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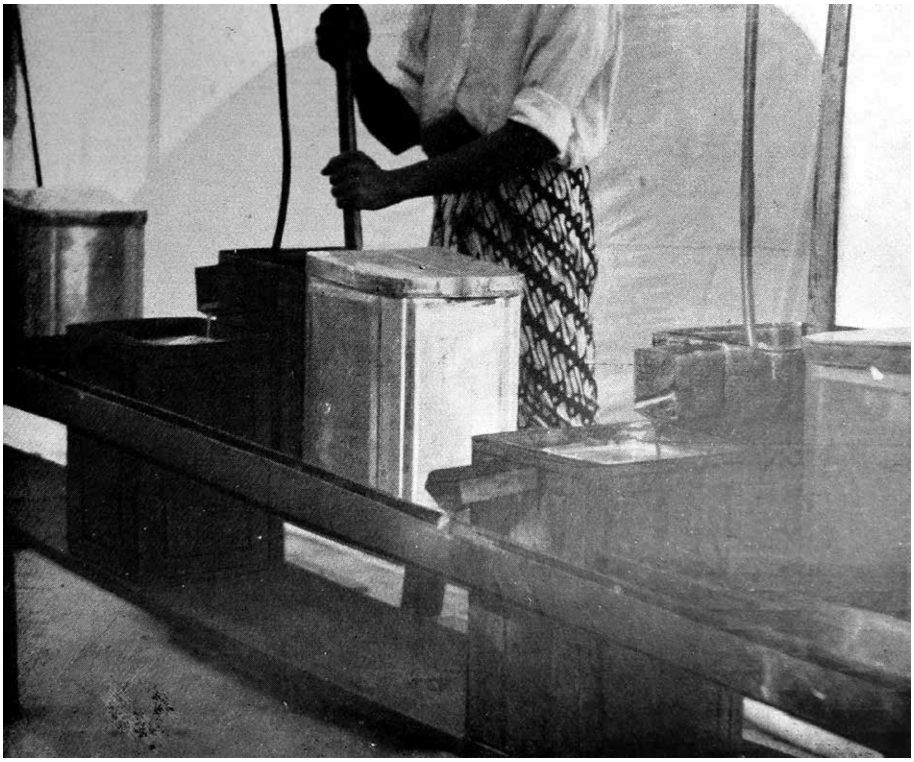


Fig. 5.4. Installation for the new method of Phytophthora-research.

Chapter 6

Jacob van Breda de Haan, 1866-1917, a forgotten plant pathologist

6.1. From Lowlands to Tropics

Jacob van Breda de Haan was born in Haarlem, the Netherlands, on 11 November 1866. His father, Daniel de Haan, was a beer brewer, a socially engaged man.[1] His mother was Jacoba Frederica van Breda. In 1884 van Breda de Haan began his study in botany at the Leyden University where his grandfather, Jacob van Breda, had been a professor of botany. Apparently young van Breda de Haan made a good impression as the professors W.F.R. Suringar and K. Martin invited him, with two contemporaries, to accompany them on a plant foray, the Dutch West Indian Expedition, 1885.[2] He came to like tropical botany making the anatomy of a Caribian plant, *Melocactus* spp, the subject of his Ph.D. thesis. The figures illustrating his thesis, written in Dutch, which van Breda de Haan defended on 13 March 1891, showed that he was an accomplished microcopist and a competent draughtsman. He resigned on 28 March 1891 as an 'assistant in botany', a part-time job 'on one half of the available annual pay'.[3]

His interest for the tropics is shown by his appointment as a member of the 'Royal Institute for Linguistics, Geography and Ethnology', 16 april 1887.[4] In 1890 van Breda de Haan, assistant in botany with a master's degree, was nominated as a teacher in natural history at the 'gymnasium' highschool in The Hague, certainly a respectable position.[5] I don't know whether he got the job but, anyhow, he did not need it. On April 11th, 1891, he boarded the steamer *Sumatra* for the Dutch East Indies, where he was appointed '*kruidkundige*' (= herbologist) at the Botanical Garden of Buitenzorg (presently *Kebun Raya Bogor*).

6.2. Career

6.2.1. Civil servant in health and disease

On October 16th, 1894, he left Batavia on board of the steamer *Princes Sophia* with destination Amsterdam, and in March 1895 he returned to the Indies with the *Lawos*. Apparently, toward the end of 1898 van Breda de Haan went once more to the Netherlands, this time on sick leave, as a certain 'Omega' wrote on February 15th, 1899, in the 'Amsterdam Letters', a gossip column in the newspaper 'De Sumatra Post': '*In my foregoing I recorded the arrival of Dr. van Breda de Haan.*

Fortunately, the faculty here declared him perfectly healthy, so that he may walk again under the palm trees confidently and unpunished'.[6] On April 18th, 1899, van Breda de Haan arrived once more at Batavia, on board of *la Seyne*. He became head of the eighth department of the Botanical Garden '*charged with the study of the living conditions, structure and diseases of tropical crops*'.[7]

In 1900 the government appointed van Breda de Haan as a civil servant-botanist to the Botanical Garden, and somewhat later as the head of the second department (botanical laboratory).[8] At the time, the health of Europeans in the Indies was vulnerable. Infectious diseases were only partly understood, at best. Antibiotics were not yet available. Several times van Breda de Haan broke down due to disease.[9] In 1900 he underwent surgery in Soerabaja.[10] In 1901 van Breda de Haan suffered from '*smashing of the leg*'; the leg should be amputated. The patient was keen enough to ask for a 'second opinion'; the leg was nicely patched up.[11]

In 1903 followed his appointment as the head of the 'Experimental station for rice and second crops', at Buitenzorg again, a research station of great importance to the domestic food crops, rice first and foremost, but also maize, peanut and others.[12] The government considered the domestic rice production to be of great importance. '*The head of the second department of the Botanical Garden at Buitenzorg, Dr. van Breda de Haan, has been granted a leave of five months to study rice cultivation in Italy and Southern France, as well as the cultivation of other cereal crops*'.[13] Thus, van Breda de Haan went on European Leave again in the second half of 1903. He participated in the 'Second International Congress for Rice Cultivation' in Mortara, Italy, and visited the Colonial Garden in Nogent-sur-Marne, France.[14]

As of Januari 1st, 1905, van Breda de Haan was appointed as the 'Inspector of the Indian Agriculture'.[15] In this title the word 'Indian' must be understood as 'indigenous' or 'domestic', in contrast to the estate agriculture producing commodities for the international market.

In 1906 he had to cancel his presence as the governmental representative at the Sugar Congress in Soerabaja.[16] In November 1906 van Breda de Haan left for a sick leave of one year; he was too ill to pay the customary good-bye visits.[17] He returned toward the end of November, 1907.[18] He became department head with the Directorate of Agriculture with, again, the title of Inspector of the Indian Agriculture.[19]

Following six years of service van Breda de Haan went on regular European Leave beginning Februari 4th, 1914. A prolongation of two months was granted in order to visit the recently chartered '*Institut International d'Agriculture*' at Rome, the predecessor of FAO (U.N. Food and Agriculture Organisation), in which the Dutch East Indies participated, and a visit to the '*Stazione Sperimentale de Rizecoltura*', the Italian experiment station for rice at Vercelli, a town in the Po valley west of Milano.[20] At the end of 1914 he resumed his work in Buitenzorg.

The newspaper 'Sumatra Post' wrote in 1917 '*As the N.v.d.D.v.N.I. learned Mr Dr. J van Breda de Haan, Inspector of the Indian Agriculture, has departed these days to Djambi for a considerable time. A journey 'right across Sumatra', but on foot, of which 350 km through Djambi's interior, is scheduled by this interesting program*'.[21]

The objective of this trip was not mentioned but can be guessed, domestic (native) cultures of rubber, cotton and rice. Complaints about the domestic rubber production were frequent, the '*usual bad Djambi quality*' was said in Singapore.[22] Somewhat later followed news '*Dr. Van Breda de Haan, on duty trip in Sumatra, fell ill. Yesterday his wife left to go there*'.[23]

On October 12th, 1917, the newspaper wrote '*Today the Inspector of Domestic Agriculture, Dr. J. van Breda de Haan, died in the Tjikini hospital here in town*'.[24] It concerned an emergency admission and an, alas, unsuccessful operation. The newspaper 'Bataviaasch Nieuwsblad' of 16 October published an obituary with photograph (Fig. 2.1). In the funeral orations his boss, Mr. Lovink, limited his praise to '*dutiful civil servant*' whereas Dr. Koningsberger, director of the Botanical Garden, stroke a warmer touch with '*excellent qualities … which were to his credit as a human being*'.[25]

6.2.2. Sugar cane

From 1891 till 1893 van Breda de Haan studied the diseases and pests of sugar cane, on behalf of the 'Sugar Research StationWest-Java'.[26] He published several papers on sugar cane (1892-1, 1893-1,2, 1894-1, 1900-3).

6.2.3. Tobacco

The beginning of tobacco cultivation in Deli on the east coast of Sumatra, was a kind of Wild West adventure (Chapter 1). Tough folks cut the jungle, hunted tigers, bullied the locals, and exploited their Chinese and Javanese coolies in an often brutal manner (Breman, 1987). Van Breda de Haan (1898-4) expressed his concern about the climatological consequences of the deforestation in Deli.[27]

A disease had suddenly appeared in the Deli tobacco that primarily damaged the young plants, the bibit, on the seed beds, but that after transplantation could also affect the older plants with foliar lesions and rotting stem base. This 'bibit disease' was the major problem. With adult plants a black stem base was the characteristic symptom, '*black shank*' in the American literature. The disease endangered the exceptionally profitable production of 'Deli tobacco' with total ruin.[28]

The visionary director of the Botanical Garden, Dr. Melchior Treub, succeeded in obtaining the consent of the government to appoint some scientists financed by private money and to sollicite money from private institutions, an early form of Public-Private Partnership.[29] Treub made a good choice: Dr. J.C. Koningsberger[30], C.J. Lohmann, and Dr. J. van Breda de Haan.

Dr. Treub lobbied intensively with the Deli tobacco planters for the appointment of a researcher.[31] February 13th, 1893, a telegram from the Deli Company in Amsterdam arrived in the Indies with the approval for '*the placement of a botanist for the said tobacco research, for a period of 5 years*'.[32] February 14th a telegram was sent to van Breda de Haan, already present in the Indies, '*with the fortunate result that he declared himself to be ready to accept this first of a new category of jobs at the Botanical Garden*'.[33] Van Breda de Haan travelled frequently from Buitenzorg to Deli where he sometimes stayed for months. The 'shipping news' of the Indian newspapers provide a nice though incomplete overview of van Breda de Haan's many voyages on the coasters of the 'Royal Packet Navigation Company'.[34]

Van Breda de Haan engaged in field research in Deli, designed a large field experiment, organised an inquiry among the plantation managers, and repeatedly presented lectures to the planters in Medan (a.o. 1894, 1897, 1901). Supplementary studies were made in Buitenzorg. A preliminary report (1893-4), possibly the upbeat for the field experiment in 1894, was praised in the newspapers.[35] He arrived at the conclusion that the disease was due to a fungus which he named 'Phytophthora Nicotianae nov. Spec.' (Chapter 3). In the final report van Breda de Haan gave a description of the fungus with good drawings (Fig. 3.2) but he omitted a formal description in Latin. He thought that a real fungal taxonomist should identify the fungus using infection experiments with a set of host plants. He contented himself with the 19th-century usage to name a newly found fungus (temporarily) after the host plant.[36] Van Breda de Haan's name is still attached to the scientific name of the pseudo-fungus:

Phytophthora parasitica Dastur var. *nicotianae* (van Breda de Haan) Tucker, or

Phytophthora nicotianae van Breda de Haan.[37]

The field experiment of 1894 was huge, with an experimental field on each of eight plantations, having different environmental conditions, and with fifty plots (i.e. seed beds) per experimental field. Two variables were applied, chemical treatment at four levels (spray schedules for Bordeaux mixture), and ecological treatment at four levels (variations in screening the seed beds). Treatments were distributed regularly over the 5 x 10 plots per experimental field with a fixed design for all eight experimental fields, as randomisation of treatments and statistical analyses did not yet exist.

A very careful analysis of the results allowed van Breda de Haan to draw some useful conclusions. Treatment of the seed beds with Bordeaux mixture was generally profitable. The ecological treatments yielded different results according to the weather conditions on the various plantations. The general recommendation was to allow more light and air to the seeds beds than local usage had dictated so far, the seed beds being shielded off from the outside weather.

Van Breda de Haan was not easily scared. Besides the field experiment he also organised an extensive enquiry among the managers of some forty plantations about the control practices, if any, of the bibit disease.[38] Again, the results were unravelled very carefully. Generally speaking the managers confirmed the insights obtained by way of the field experiment. For the rest, van Breda de Haan was reticent in his conclusions; for example, he was reasonably certain of the pathogen's identity, but he could not exclude the possibility of unwanted infections in his laboratory experiments (p 63). He knew the value of 'controls' (p 66, 72).

The financial interests in Deli were enormous because it was feared that the tobacco cultivation would break down completely due to the bibit disease. Van Breda de Haan must have felt the pressure. He made good time, two interim reports (1893-4, 1894-2) were followed by the final report, completed in November 1895 and printed in 1896. The language used points to great urgency; it is hasty, sloppy, repetitive, with long and incoherent sentences, and illogical tenses. The wording and the structure of the sentences is often at primary school level, unmistakably aimed at financiers and managers without any notion of phytopathology. This style was in obvious contrast to the deliberate, scientific writing style in his Ph.D. thesis and his later publications, all in Dutch.

Besides the bibit disease van Breda de Haan studied the 'tobacco nematode' (1896-2, 1899-2). The mosaic disease of tobacco presented another intriguing problem. In 1906, the 'Sumatra Post' discussed the 'Mosaic disease of tobacco' following a 1905 paper by F.T.W. Hunger and stated that '*van Breda de Haan found in 1899 a bacterium in the diseased tissue, which he also isolated and considered to be the virus of the disease*' (1998-3).[39] The slime disease (bacterial wilt) of tobacco, now known to be caused by *Pseudomonas solanacearum* E.F. Smith, was recognised as a bacterial disease (1898-2).

During several years van Breda de Haan stayed in close contact with the tobacco growers in Deli by means of lectures,[40] reports (1893-4, 1894-2, 1896), publications (e.g. 1893-3, 1895-1) and newspaper communications (e.g. 1895-2).

6.2.4. Rice

The tobacco studies finished, van Breda de Haan in his new job concentrated on rice.[41] Early in 1901 van Breda de Haan visited the residence Semarang (N Java) where a rice disease called *mentèk* or *beloek* reigned widely. Van Breda de Haan placed an annoucement in the newspapers asking the public to report, a very modern approach![42] Alas, even an accomplished scientist may make mistakes. Van Breda de Haan (1901-2) made a detailed study of this disease, also called *omo mentèk* or *omo bambang*.[43] He identified the causal agent as a nematode, *Tylenchus Oryzae*, later renamed *Radopholus oryzae* (van Breda de Haan) Thorne. Later research did not confirm this attribution, though it was confirmed that the nematode could indeed damage the rice crop (van der Vecht, 1953). Much later, *omo mentèk* has been recognised as 'tungro', caused by a combination of two viruses, rice tungro bacilliform virus (RTBV) and rice tungro spherical virus (RTSV), both transferred by Jassids. The nematode is generally present on rice and rice weeds but it is not guilty of tungro (Webster & Gunnell, 1992). For the public in the mother country van Breda de Haan wrote an overview of rice cultivation in the Dutch East Indies (1916-3).

The newspapers in the Dutch East Indies showed a lively interest in scientific publications. The content of the scientific journal 'Teysmannia', a journal for botany and agriculture publishing in the Dutch language, was quoted regularly.[44] The study on *omo mentèk* was intensely discussed, with pro's and con's, as e.g. in "De Locomotief" ('*not a* birth *but an* infection *disease*') and the 'Sumatra Post'.[45] The 'Soerabaijasch Handelsblad' dedicated a long discussion to van Breda de Haan's treatise on *padi gogo*, the dry rice cultivation (1903-2).[46] The 'Sumatra Post' discussed van Breda de Haan's paper on floating rice (1903-6).[47] Van Breda de Haan himself touched a tender spot when elaborating on the rising price of rice in the Indies, its economic background and its possible social consequences.[48]

6.2.5. Cotton

Van Breda de Haan developed a great interest in cotton production, especially by the peasant farmers. Again, the newspapers showed a lively interest. One newspaper published an overview of the experiments with cotton growing in Palembang, Sumatra.[49] Van Breda de Haan thought the progress far too slow, more extension was needed. Meanwhile Dr. D.J.G. van Setten was stationed on the spot to manage the cotton experiments.[50] The 'Sumatra Post' discussed the report over 1911 by the 'Society for the Promotion of the Cotton Cultivation in the Dutch Colonies'.[51] In November 1911 van Breda de Haan presented a paper on cotton production to the International Fiber Congress in Soerabaja.[52] '*Under the present circumstances the domestic production (in Palembang) has demonstrated its viability and is of great importance for the local populace*'.[53]

The Director of Agriculture, mr. H.J. Lovink, wanting to acquaint himself with the cotton cultivation in Southern Sumatra, visited the experiments by Dr. van Setten near Moeara Enim, in the Palembang area, accompanied by van Breda de Haan.[54] With one day extra to spend they also went to see the floating rice of the tidal sawahs.[55] The 'Nieuws van de Dag' discussed a general overview of the cotton production in 1914.[56] One obituary mentioned a duty trip to Queensland, Australia, in about 1915, to study the cotton cultivation.[57] In the end, alas, little did come of cotton cultivation because the matter '*was handled with too little expertise and too little energy*'.[58]

6.2.6. Agricultural meteorology

Van Breda de Haan (1901-2) had an interest in agricultural meteorology and, apparently, stimulated the fitting up of some meteorological stations. He introduced the meteorological tables published by the National Botanical Garden, mentioning the instruments to be used and the measurements to be made as well as those not to be made (atmospheric pressure, day length, wind speed and wind direction). He did not want a met station as part of a meteorological network because the site was inappropriate for this purpose. His objective was a station for applied meteorology to be used in phyto-physiological and ecological studies. His station, located in the Botanical Garden at Buitenzorg, should mimic the situation in a local secondary forest, always humid, with dense undergrowth. Some observations such as rainfall were made several times a day, to register heavy showers, and the usual pentad averages were rejected as unfit for the purpose. I could not lay hands on the details but it seems that this agrometeorological station was van Breda de Haan's initiative.

6.2.7. Miscellaneous

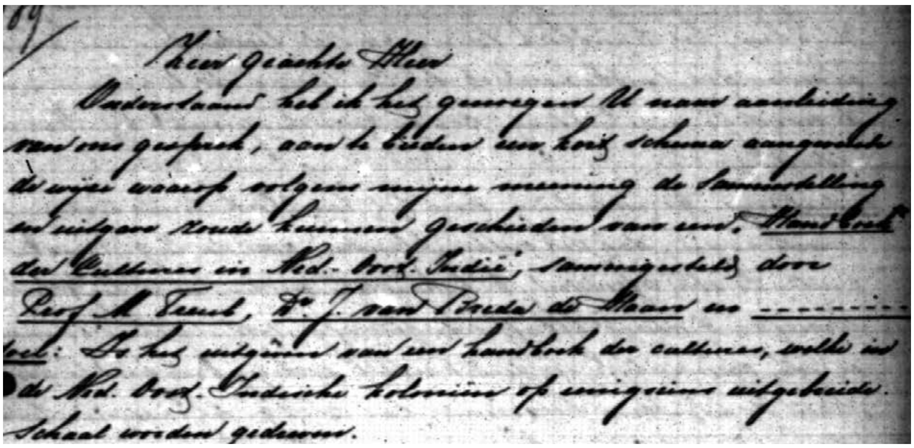
The studies of diseases and pests of sugar cane have been mentioned before; prevention was better than cure (1892, 1893-1,2, 1894-1, 1900-3). Late in 1899 van Breda de Haan was casually consulted on coffee growing in Serdang (Northeast Sumatra); he considered it a hopeless case. In 1900 van Breda de Haan made an inspection trip to Soerakarta (Mid Java) to study crop diseases. He made several other duty trips, mainly on Java, as e.g. to see peanut diseases *in loco* in the residence Cheribon and another one to Wonosobo to inspect tobacco, both in 1906.[59]

Van Breda de Haan participated in several congresses, such as the 5th Sugar Congress in Soerabaja, March 1901, the 6th one in Semarang, 1903, and the 7th in Soerabaja again, 1905.[60] He was welcomed as an important expert, sometimes also as the representative of the Government. Van Breda de Haan lectured to the 7th Coffee Congress at Malang, 1904, on pepper: '*Something on healthy and diseased pepper plants*'.[61] He addressed the International Fiber Congress, Soerabaja, 1911.

In 1903 van Breda de Haan proposed to Sijthoff's Publishing Company, Leiden, to produce a book indicated as 'Handbook of the cultures in the Dutch East Indies', to be edited by Professor M. Treub, van Breda de Haan himself and a yet unnamed person.[62] Typically, the book was to address the practice of crop production; it should not be an abstract scientific treatise. This project was not realized, for reasons unknown. The proposal was made by letter showing that van Breda de Haan's neat, regular handwriting on squared paper was ideal for the typesetters (Fig. 6.1).

From 1903 to 1906 van Breda de Haan was an editor of the journal 'Teysmannia', organized by the Botanical Garden. For many years van Breda de Haan served as the secretary-treasurer of the 'Society for Fruit Growing', a society with some 300 members scattered over several local departments.[63] Apparently van Breda de Haan took an interest in *bonsai*. With H.J. Wigman, hortulanus of the Botanical Garden, he sent *tjankokans* (miniature trees) to the 1903 exhibition at Demak (North Java), a small town accessible by tram from Semarang.[64]

Van Breda de Haan had to deal with various accidental matters such as a parasitic plant of coffee belonging to the family of the Balanophoraceae (1903-5), something on pepper (1904-9,12) and vanilla (1905-2), ring rot of potato (1903-9) and false mildew of grape (1905-5). Van Breda de Haan and others expressed their concern about the neglect of the domestic rubber production in Palembang and Djambi.[65]


69

Hooggeachte Heer
Onderstaand heb ik het genoegen U naar aanleiding
van ons gesprek, aan te bieden een kort schema aangevende
de wijze waarop volgens mijne meening de samenstelling
en uitgave zoude kunnen geschieden van een "Handboek
der Cultures in Ned.-Oost-Indië", samengesteld door
Prof. M. Treub, Dr. J. van Breda de Haan en ....
Doel: Bij het uitgeven van een handboek der cultures, welke in
de Ned. Oost-Indische koloniën op eenigszins uitgebreide
schaal worden gedreven.

Fig. 6.1. Sample of van Breda de Haan's handwriting.

We may speculate about van Breda de Haan's attitude toward the indigenous people. As the Inspector of the Indian Agriculture and as a member of investigation committees van Breda de Haan had to interview many natives, from the assistant-resident to the simple rice farmer. Malay words had pervaded the management speak of the estates, certainly on Java. We may safely assume that van Breda de Haan had at least a working knowledge of Malay (the *lingua franca* of the archipelago), and maybe he even knew some Javanese (a very different language). Without respect and patience no sensible answers can be obtained.[66] Van Breda de Haan was certainly able to extract meaningful answers from his respondents. As a high-placed civil servant he had the paternalistic outlook of his time, but with a modern ethical touch as expressed in the term 'brown brother' in a sentence from a paper on a transmigration project on the verge of failure. '*Alas, once more it appeared here that even the best care and the greatest support have not yet the magic power to change the weak brown brother into a colonist, answering the expectations cherished by the Government*'.[67]

6.2.8. Investigations

In 1902 Mid Java suffered from inadequate irrigation and hence from food scarcity.[68] The Governmental Decree no. 8 of July 2nd, 1902, established a Committee of Investigation. One of the members was the officer–botanist van Breda de Haan.[69] Some members, among whom van Breda de Haan, visited the regency Grobogan to acquaint themselves with the problems but many analyses were entrusted to local officials.[70] In December, 1902, already the Committee submitted her report to the Governor-General.[71] The report was published in 1903.[72] The Indian press was quite sceptical about the report that, according to some, only tried to conceal the mismanagement by the government.[73]

Another Committee of Investigation was appointed by governmental Decree no. 31 of October 15th, 1902, with van Breda de Haan as one of its members again. The Committee was to organize and supervise an investigation into the reasons of the reduced welfare of the native population on Java and Madoera. In 1908 van Breda de Haan was '*on request honourably discharged as member of the leading committee charged with the investigation of the reasons for the decreased welfare of the native population on Java and Madoera …with thanks*'.[74] The final report was published in 1914, a treasure trove of information, containing far over 2000 pages (Anonymus, 1914).

6.3. Publications

As a beginning researcher van Breda de Haan published several scientific reports and papers. Later he also published reviews (1900-1, 1903-10, 1906-3), travel accounts (1904-3,10,14), policy oriented papers (1902-2, 1903-4, 1914-1,2,3) and extension material (1905-8, 1911-2). He thought that the natives could improve their yields considerably by better tillage (1897-1). When he became a high ranking civil servant in the Department of Agriculture his freedom to publish under his own name decreased. Doubtless the Annual Reports of the Department of Agriculture contained many of his insights. A list of his publications, probably non-exhaustive, is added as Annex 4.

6.4. Food scarcity

Under the pseudonym Multatuli a man named Eduard Douwes Dekker published the Dutch novel 'Max Havelaar' in 1860.[75] The author, having been a civil servant in the Dutch East Indies, was incensed by the treatment of the natives. The novel, translated into several West European languages, sent moral shock waves through the benevolent European public. Around 1900 the Indian Government too began to ponder on the wellbeing of the 'native'. He should work, but to work hard he had to feed himself properly. Consequently, the native, domestic, or more nicely 'Indian' agriculture should be given more attention. Per Januari 1st, 1906, a Department of Agriculture was established, that should mark a new era.[76] The first and most important section was that of the Indian Agriculture, with an Inspector, extension personnel and an experiment station for rice and second [*palawiya*] crops.[77] Rice was the staple of the Javanese population, supplemented by maize and peanut. Van Breda de Haan's mission to Italy in 1903 was already meant to upgrade the available knowledge on rice growing.

6.5. A painful affair

Mr. H.J. Lovink (1866-1938), a self-made man, was a highly praised Director-General of Agriculture in the Netherlands (1901-1909).[78] '*The Dutch farmers considered his departure to be little less than a national calamity*'.[79] In 1909 he went to the Dutch East Indies to become Director of Agriculture, Industry and Trade. Lovink was a bold man with vision, a man of broad outlines, who was much criticized but also won great approval.[80] '*The Indies have to consider themselves lucky with a man heading the important department of agriculture who has the ability to read on his internal compass the social-economic course that has to be steered*'.[81]

Lovink operated quite self-willed and he antagonised many persons making himself enemies of them. The contribution of older officials like van Breda de Haan, more experienced in Indian affairs, was often neglected. '*The director of agriculture in the Indies has thus to exercise self-knowledge in the first place; this is not made easy by his thirst of 'authority-fullness*''.[82] '*Each of his actions is pervaded by his natural aptitude for publicity*'.[83] The impression is created that Lovink and van Breda de Haan could not get on, possibly an *incompatibilité d'humeurs*.

Two of Lovink's plans failed, one for starting domestic tea production and another one for promoting native wheat growing. The local population could not sell her tea and starved due to lack of income. The government paid dearly for corrective measures and compensations. In the Indies growing wheat was feasible but not as a peasant crop.[84] In both cases Lovink had disregarded van Breda de Haan's warnings.[85] Lovink was given a bad press.[86] '*But when mister Lovink says white to be black, it remains black. As a result the population was hard up*'.[87]

The First World War did, of course, not pass unnoticed by the Dutch Indian Government. In 1916 a committee should consider the food supply of Java and Madoera, the most densely populated islands of the archipelago. Van Breda de Haan had collected many data arranging them in maps and statistics and thus he had gone a long way in answering the question. Lovink, however, laid aside the report on the food supply of Java and Madoera in case of an enemy attack, as drafted by van Breda de Haan, '*this officer always defamed from above and consistently set back*'.[88] He brought forward another, more optimistic view, not based on facts.[89] Following van Breda de Haan's death his widow went to the palace of the Governor-General, Dr. J.P. Count van Limburg Stirum, to hand over her husband's report belatedly. The Governor-General then put Lovink on the spot; it must have been an awkward conversation.[90] Lovink resigned for '*reasons of health*'.[91]

6.6. Final comments

Little is known about van Breda de Haan's private life. His engagement with Lize (Elisabeth Jannetje) Schaap was celebrated with a reception at the home of his colleague Dr. J.C. Kramers, 9 Februari 1904. The marriage licence was taken out on April 4th and the wedding took place on May 9th, 1904, all this in Buitenzorg.[92] In 1909 van Breda de Haan advertised '*For sale a couple of excellent Australian carriage horses, also going single. Apply with …*'.[93] Did he change over to the nice automobile that later was offered for sale?

Following van Breda de Haan's early death various matters had to be settled. His widow's démarche, probably also intended as a rehabilitation, has been mentioned. House and movables were sold by auction, including gas lamps and an 'Automobile Delaunay Belleville', at the time the most prestigious make of car.[94] Obviously, van Breda de Haan had collected folk art, including textiles. The widow gave the important library of her husband, together with his portrait, to the 'Society for the Advancement of the Library System in the Dutch East Indies' under the designation 'Library van Breda de Haan', public reading room, Koningsplein Zuid No. 11.[95]

The Government showed its appreciation by knighting van Breda de Haan as Officer in the Order of Orange-Nassau in 1909.[96] In 1913 the French Government appointed him Commander in the Order of the Dragon of Annam.[97]

Chapter 7

Epilogue

In this book three foundational papers on the black shank disease of tobacco, 1896, 1931 and 1938, are presented in English. They are preceded by a brief introduction on tobacco growing the former Dutch East Indies, present Indonesia, and supplemented by a biography of the long forgotten Dr Jacob van Breda de Haan, author of the first of these three papers. Short biographies of the second author, Dr Thung Tjeng Hiang, were published earlier (a.o. Kerling, 1961; van der Want, 1961).

The two key words of this volume are 'black shank' and 'epidemiology'. Three papers on 'black shank' from the former Dutch East Indies, published in the Dutch language, show the time course of these two concepts in parallel. The 1896 paper testifies of the struggle to identify the causal agent. At the same time, the paper offers a choice of epidemiological titbits, scattered, and without consistence yet. The enlightened 1931 paper, which compares black shank with two other tobacco diseases, forges epidemiology into a descriptive tool. The 1938 paper is a comprehensive analysis of black shank epidemiology, a prelude to the modern 'landscape epidemiology'.

The Dutch approach to crop protection problems in the former Dutch East Indies had some typical characteristics. *1*. The papers are very scientific in approach but typically practice oriented, aimed at solving problems rather than at producing science. *2*. They are written in Dutch, immediately addressing the user of the information produced. That may be one reason that these papers are written in an elaborate style, to make them understood by readers not trained in science. *3*. They are usually funded by private money, not state money, though the government may have given some support. *4*. The researchers working in outposts were relatively isolated, without the modern academic and technological support.

These four points characterize a great deal of the good research in crop protection done in second half of the 19th and the first half of the 20th centuries in the former Dutch East Indies. It is my pleasure to honour two scientists from that period by means of the present publication. Their reports addressed an audience of financiers, officials, planters, and literate personnel. Most readers must have been insiders, familiar with the customary local terminology, be it in Dutch, Malay, or Javanese.

The botanist van Breda de Haan was a real pioneer entering an unknown and foreign world, facing both a new plant disease and worried sponsors. Thung, thoroughly trained in plant pathology, worked in an organized and stable environment. As to controlling the black shank pathogen of tobacco, van Breda de Haan laid the foundation, Thung brought the refinement.

Thung's 1931 paper presages modern, post-1945 developments: emphasizing epidemiology as an objective *per se* and as a tool, fumbling at comparative epidemiology, playing with numbers to see epidemics grow differently, with just a hint of new theory.

The papers presented in Chapters 3 and 5 differ in two respects. First, Van Breda de Haan worked in an extensive cropping system, with rotation periods of ~10 years, whereas Thung analysed an intensive system, with a rotation period of two years. Second, Van Breda de Haan was primarily interested in the nursery bed phase, Thung rather emphasized the field crop phase of tobacco production.

Both authors discussed ecological, chemical, and genetic remedies. Whereas van Breda de Haan could dream only of resistance breeding as a remote possibility, Thung could incorporate a new and fairly resistant tobacco variety in his disease control system.

Whereas van Breda de Haan was pioneering in phytopathological research, Thung was rather refining the tobacco production system. According to the standards of their time, both studies were original and of an exceptionally high quality. The two scientists offered solutions that could be applied profitably.

Both papers are 'transitional', in the recent meaning, since scientific analysis led to clinical application. In more familiar terms, the two studies rendered here in chapters 3 and 5 were very much practice-oriented. The scientists offered solutions that could be applied professionally. In this respect the papers fit in the strong tradition of tropical phytopathology as developed in the Dutch East Indies before World War II.[1]

Annexes

Annex 1 - Tobacco calendar of the Principalities in the 1930s

Indicative calendar of the *Vorstenlanden* tobacco estates. Weather data are recent, averaged over the whole of Java, source: www.klimaatinfo.nl/indonesie/java.htm

Month	Rainfall	Sunshine	Raindays	Tobacco		Rice
				early	late	
August	<100	9	17	sowing		
September	<100	9	16		sowing	
October	101-200	8	19			
November	>200	7	24			
December	>200	6	25	pulling stubs, undersowing crotalaria		Seedbed preparation
January	>200	4	24		pulling stubs	transplanting
February	>200	6	23	cutting crotalaria		
March	>200	7	26			
April	>200	8	18	carting manure		
May	101-200	8	13		carting manure	
June	<100	8	14			
July	<100	9	16			

Rainfall – approximate rainfall in mm per month.
Sunshine – monthly mean in hours per day.
Rain days – mean number of rain days per month.
Tobacco – approximate timing of operations.
Rice – approximate timing of first rice crop following tobacco.

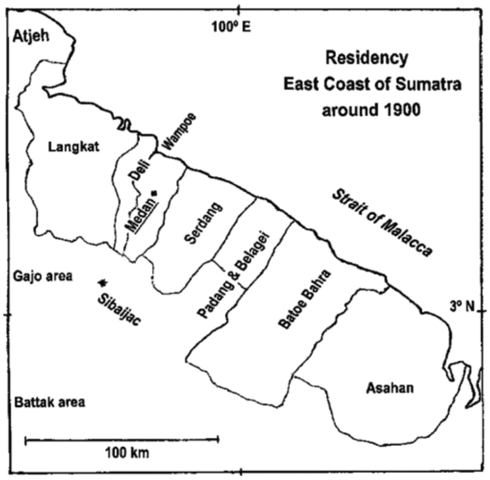
Annex 2 - Geographical notes

Sumatra's most northern province is Atjeh. To its south is the province North Sumatra with the capital Medan.

The former residency Sumatra's Oostkust (Sumatra's East Coast) is the eastern part of the province North Sumatra, bordering the Strait of Malacca. It consisted of a number of regencies (Indonesian: *kabupaten*), from north to south Langkat, Deli (with the town Medan), Serdang, Padang bedagai, Batoe Bahra, Asahan (See map). The present arrangement is Langkat, Deli Serdang, Serdang bedagai, Batu bara, Asahan. The Gajo area lies more inland, west of Langkat. The Battak area is south-west of Deli, around the Lake Toba.

The island Sumatra is rich in volcanoes of which the one mentioned is the Sibaijac.

Author's spelling	Indonesian spelling
Assahan	Asahan
Atjeh	Aceh
Batavia	Jakarta
Batoe Bahra	Batu bara
Battak	Batak
Bengkoelen	Bengkulu
Besitan	Besitang
Buitenzorg	Bogor
Cheribon	Cirebon
Deli	Deli Serdang
Djambi	Jambi
Gajo	Gayo
Jogjakarta	Yogyakarta
Kinabatangan	Kinabatangan
Langkat	Langkat
Limbatoe	Limbatu
Madoera	Madura
Medan	Kota Medan
North Sumatra	Sumatera Utara
Padang Bedagai	Deli Serdang
Province	Provinsi
Serdang	Deli Serdang
Sibaijac	Sibayak
Sumatra	Sumatera
Soerabaja	Surabaya
Soerakarta	Surakarta
Wampoe	Wampu



Annex 3 - Indonesian terminology

In the text the original Dutch transcription of Malay or Indonesian words was maintained. The Dutch vowel *oe,* written as *u* in Indonesian, is pronounced in English *oo* as in *book*.

Manuscript spelling	Indonesian spelling	English
Alang alang	*alang alang*	blady grass = *Imperata cylindrica* (L.) Beauv.
Atap	*atap*	roof(covering)
Bandjir	*banjir*	flood, spate, freshet
Bibit	*bibit*	seedlings, plantlets grown on seedbeds to be transplanted
Boesoek	*busuk*	rotten, bad, smelly, stinking
Bouw	*bahu*	7906.5 m^2 = ~0.8 hectare
Tjankokan	*cangkokan*	Miniature plant (from *cangkok* = graft)
Dessa	*desa*	village
Djarak kepiar	*jarak tumbuhan*	castor oil plant = *Ricinus communis* L. [b]
Djarak pager	*jarak pagar*	Barbados nut = *Jatropha curcas* L. [c]
Djeroek	*jeruk*	*Citrus* L.
Kaki	*kaki*	foot, leg
Kaki boesoek	*kaki busuk*	rotten foot/leg
Kampong	*kampung*	village
Kedele	*kedele*	soybean = *Glycine max* (L.) Merr.
Ketela	*ketela rambat*	sweet potato = *Ipomoea batatas* L. [d]
Ketella	*ketela pohuns*	cassava = *Manihot utilissima* Crantz [e]
Kongsi	*kongsi*	team, organized group [f]
Kongsiekan	*kongsikan*	working together, in a team
Ladang	*ladang*	arable land (not irrigated), swidden
Lalang	*lalang*	*alang alang* vegetation
Lanas	*lanas*	overheated, wilted, dead [a]
Loengoeh	*lungguh*	*ex officio* field, governmental land for village officials [a]
Loh	?	*Tabernaemontanum sphaerocarpa* Bl.
Na-nglebben	-	second irrigation, Dutch transformation of Javanese word
Nglebben	-	Dutch form of local word for 'to irrigate' [a]
Ngleb	*ngeleb*	to irrigate (leading water to successive plots) [a]
Padi	*padi*	paddy, rice (plant, crop, seed)
Palawiya	*palawija*	non-rice crops (following rice)
Papaw	*papaya*	*Carica papaya* L.
Pematan	*pematang*	ridge, bund
Randoe	*pohon kapuk* [g]	*Ceiba pentandra* L. Gaertn. [h]
Sawah	*sawah*	flooded rice/paddy field
Terong	*terung*	eggplant = *Solanum melongena* L.
Tinkap	*tingkap?*	mat woven of plant material
Tjankokan	*cangkokan*	miniature tree (from *cangkok* = graft)
Tjankol	*cangkul*	hoe
Tunas	*tunas*	bud, sprout, lateral shoot
Waroe	*pohon waru*	sea hibiscus = *Hibiscus tiliaceus* L. [i]
Wedan	*wedang*	boiled fluid [a]
Wedangan	*wedangan*	looking as being boiled or overheated [a]
Widji	*wiji*	seed [a]
Widjinan	*wijian* (?)	seed bed(s)

[a] Javanese
[b] *tumbuhan* = plant
[c] According to Thung = *Hibiscus macrophyllus* Rexb.
[d] *rambat* = spreading (creeping plant)
[e] *pohon* = tree (erect plant)
[f] originally Chinese word
[g] also *pohon randu, kapuk randu*
[h] According to Thung = *Eriodendrum anfractuosum* D.C.
[i] *pagar* = hedge

Annex 4 - Publications by Jacob van Breda de Haan

* Short note.
** Review paper.
*** Not retrieved by present author.
[modern Indonesian spelling]

1891-1. Anatomie van het geslacht *Melocactus*. Haarlem, Enschedé. Ph.D. Thesis. (*Anatomy of the genus Melocactus*).

1892-1. Rood-rot en andere ziekten in het suikerriet. 38 pp. Semarang, van Dorp, p 7. (*Red rot and other diseases in sugar cane*). Also in: Mededeelingen van het proefstation voor suikerriet in West-Java te Kagok-Tegal.

1893-1. Rietvijanden onder de insecten en hunne bestrijding. Teysmannia 4: 260-274. (*Cane enemies among the insects and their control*).

1893-2. De gele-strepenziekte bij het suikerriet. Teysmannia 4: 513-522. (*The yellow stripe disease of sugarcane*).

1893-3**. Boullie bordelaise en hare toepassing. Teysmannia 4: 720-733. (*Bordeaux mixture and its application*).

1893-4. Voorlopig rapport over de bibitziekte in de tabak. Batavia, Kolff. (*Preliminary report on the bibit disease of tobacco*).

1893-5**. Eene nieuwe suikerriet-ziekte in West-Indië. Teysmannia 4: 544-548. (*A new disease of sugar cane in the West Indies*).

1893-6*. Droog en nat rot bij de tabak. Teysmannia 552-554. (*Dry and wet rot in tobacco*).

1894-1**. Sereh en andere rietziekten in Australie. Teysmannia 5: 65-70. (*Sereh and other cane diseases in Australia*).

1894-2. Rapport over de proefnemingen ter bestrijding der bibitziekte in de tabak. Batavia, Kolff. (*Report on the experiments to control the bibit disease in the tobacco*).

1895-1. Het aanaarden bij de tabak in Deli. Teysmannia 6: 700-711. (*Earthing up the tobacco in Deli*).

1895-2***. Over toppen en tunassen. Deli Courant (volgens De Locomotief 5 juni 1895). (*On removing tops and lateral shoots*).

1896-1. De bibitziekte in de Deli-tabak. Mededeelingen van 's Lands Plantentuin. Nr. 15. Batavia, Kolff. 107 pp + plaat. (*The bibit-disease in the Deli-tobacco*).

1896-2. Een ziekte in de Deli-tabak veroorzaakt door het tabaks-aaltje. Voorlopige mededelingen van 's Lands Plantentuin. (*A disease in the Deli-tobacco caused by the tobacco nematode*).

1897-1. De wortels in het huishouden der plant. Teysmannia 7: 385-400. (*The roots in the plant's household*).

1898-1. Tabakszaad uit Deli. Teysmannia 8: 65-91. (*Tobacco seed from Deli*).

1898-2. De slijmziekte bij de tabak in Deli. Teysmannia 8: 528-549. (*Bacterial wilt of tobacco in Deli*).

1898-3. Het peh-sem of de mozaiek-ziekte in de tabak te Deli. Teysmannia 8: 567-584. (*The peh-sem or the mosaic disease in the tobacco at Deli*).

1898-4. Regenval en reboisatie in Deli. Batavia, Kolff. Mededeelingen uit ‘s Lands Plantentuin 23: 1-48 pp + tables & graphs. (*Rainfall and re-afforestation in Deli*).

1899-1**. Middelen tegen plantenziekten. Teysmannia 9: 451-463. (*Remedies against plant diseases*).

1899-2. Levensgeschiedenis en bestrijding van het tabaks-aaltje (*Heterodera radicicola*) in Deli. Mededeelingen uit ’s Lands Plantentuin no. 35. Kolff, Batavia. (*Life history and control of the tobacco nematode (Heterodera radicicola) in Deli*).

1900-1**. Kromme wortels en hun zijwortels. Teysmannia 10: 505-514. (*Crooked roots and their lateral roots*).

1900-2. Le tabac. Pp 144-148 in: Kan, C.M., Bosboom, H.D.H., Hooijer, G.B., Pleijte,. C.M. : Guide à travers la section des Indes-Néerlandaises (groupe XVII), Exposition Universelle à Paris 1900. La Haye, s.n. (*The tobacco*).

1900-3***. Roodrot en andere ziekten in het suikerriet. Archief voor de suikerindustrie . (*Red rot and other diseases in the sugar cane*).

1900-4**. Over het effect van bliksem op bomen. Teysmannia 10: 615-617. (*On the effect of lightning on trees*).

1901-1. Een aaltjes-ziekte der rijst “omo mentèk” of “omo bambang”. Voorlopig rapport. Kolff, Batavia. Mededeelingen uit ’s Lands Plantentuin 35: 1-65. (*A nematode disease of the rice “omo mentèk” of “omo bambang”*).

1901-2. Tableaux météorologiques tirés des observations faites au Jardin Botanique de Buitenzorg en 1901. Avant-propos. (*Meteorological tables drawn from the observations made at the Botanical Garden of Buitenzorg in 1901. Foreword*). 1 page and 11 monthly tables (January fails) in folio format.

1902-1**. De hygiëne der plant. Teysmannia 12: 536-541. (*The hygiene of the plant*).

1902-2. Zaad-wisseling bij de rijst-cultuur. Gevaren en voordeelen. Teysmannia 13: 91-105. (*Seed exchange in rice cultivation. Dangers and advantages*).

1903-1. Het indrogen van padi. Bataviaasch Nieuwsblad 17 juli 1903: p1-2. (*The drying in of pady*),

1903-2. Eenige opmerkingen over rijst-teelt op drooge gronden en drooge kweekbedden. Teysmannia 14: 63-74, 118-127.[1] (*Some comments about rice growing on dry soils and dry seed nurseries*).

1903-3. Het bewaren van de kiemkracht bij castillao- en cacao-zaad. Teysmannia 14: 137-139. (*The preservation of the germination capacity of castillao and cocoa seeds*).

1903-4. Een en ander over boomgaarden en irrigatie. Teysmannia 14: 163-171. (*Something on orchards and irrigation*).

1903-5. Een eigenaardige koffie-parasiet.[2] Teysmannia 14: 183-187. (*A peculiar coffee parasite*).

1903-6. Drijfrijst. Teysmannia 14: 215-226. (*Floating rice*).

1903-7. Tegal-koempoelan. Teysmannia 14: 279-285. (*Tegal-koempoelan [kumpulan]*).

1903-8. Het indrogen van padi. Teysmannia 14: 277a-282a. (*The drying in of padi*).

1903-9. Zwarte aardappels. Teysmannia 14: 343-351. (*Black potatoes*).

1903-10**. Zintuigen der plant. Teysmannia 14: 463-471, 579-587. (*Senses of the plant*).

1903-11*[3.] Verslag over den waters- en voedingsnood in de residentie Semarang, uitgebracht door de Commissie ingesteld bij Gouvernementsbesluit dd. 2 Juli 1902 no. 8. Buitenzorg, Buitenzorgse drukkerij. 2 delen. (*Report on the water and food problems in the residence Semarang*).

1904-1**. Het uitstoelen der rijstplant. Teysmannia 15: 13-21. (*The tillering of the rice plant*).

1904-2. Een bezoek aan den Jardin d'Agriculture te Nogent sur Marne. Teysmannia 15: 84-91. (*A visit to the Garden of Agriculture at Nogent sur Marne*).

1904-3. Maïscultuur in Noord-Italië. Teysmannia 15: 153-156. (*Maize cultivation in North-Italy*).

1904-4**. Proeven van immunisatie van planten tegen ziekten. Teysmannia 15: 220-228. (*Experiments to immunise plants against diseases*).

1904-5. Nogmaals drijfrijst. Teysmannia 15: 357-360. (*Floating rice once more*).

1904-6*. Desinfectie van katoen-zaad. Teysmannia 15: 365. (*Disinfection of cotton seed*).

1904-7*. Cassave stijfsel. Teysmannia 15: 366. (*Cassava paste*).

1904-8*. Mahonie-hout in Engeland. Teysmannia 15: 366. (*Mahogany wood in England*).

1904-9. Wortel-ziekte bij de peper op Java. Teysmannia 15: 367-386. (*Root disease in pepper on Java*).

1904-10. Mededeelingen omtrent de rijstcultuur in Noord-Italië. Teysmannia 15: 428-437, 466-474, 525-533. (*Communications on the rice cultivation in North-Italy*).

1904-11**. Spontane generatie. Teysmannia 15: 595-602. (*Spontaneous generation*).

1904-12. Iets over gezonde en zieke peper. Teysmannia 15: 645-669. (*Something on healthy and diseased pepper*).

1904-13**. Cauliflorie (Stambloeiers). Teysmannia 15: 721-733. (*Cauliflory (Stem fruiting)*).

1904-14. De huidige stand der rijstcultuur in Noord-Italië. Kolff, Batavia. Mededeelingen uit 's Lands Plantentuin 74: 1-74. (*The actual situation of the rice cultivation in North-Italy*).

1904-15**.** Wortel-ziekte bij de peper op Java. Korte Berichten uit 's Lands Plantentuin. (*Root-disease of pepper on Java*). Also in Teysmannia 15 (1904) 367-386.

1905-1. Iets over paggers [= heggen]. Teysmannia 16: 79-85. (*On paggers [= hedges]*).

1905-2. Een nieuwe ziekte in de vanielje. Teysmannia 16: 145-153. (*A new disease in the vanilla*).

1905-3**. Bestrijding der mozaiek-ziekte bij de tabak. Teysmannia 16: 177. (*Control of the mosaic disease of tobacco*).

1905-4**. Lichtgevende planten. Teysmannia 16: 221-232, 260-269. (*Light emitting plants*).

1905-5. Valsche meeldauw bij den wijnstok in Ned-Indië. Teysmannia 16: 286-288. (*Downy mildew of grape in the Dutch Indies*).

1905-6**. Loranthaceae. Teysmannia 16: 329-337, 398-410. (*Loranthaceae*).

1905-7**. Ziekte-leer der planten. Teysmannia 16: 447-459, 511-529. (*Pathology of plants*).

1905-8. Een en ander over het toppen. Teysmannia 16: 603-615, 668-679, 703-716. (*Something on topping*).

1905-9**. Een wedstrijd met pulverisateurs. Teysmannia 16: 730-735. (*A contest with pulverisers*).

1906-1. Rapport over ziekte in den aanplant van *Arachis hypogaea* (*katjang holle*) in de afdeelingen Koeningan en Cheribon der residentie Cheribon. October 1905. Teysmannia 17: 52-63. (*Report on disease in Arachis hypogaea in the sections Koeningan [Kuningan] and Cheribon [Cirebon] of the residence Cheribon*).

1906-2**. Het zuiveren van bevloeiingswater door kopersulfaat. Teysmannia 17: 285-293. (*The purification of irrigation water by means of copper sulphate*).

1906-3**. Iets uit de geschiedenis van de leer der plantenziekten . Teysmannia 17: 438-446. (*Something from the history of plant pathology*).

1906-4. Verslag over de tabakscultuur in het district Garoeng der residentie Kedoe. Teysmannia 17: 509-527, 579-591. (*Report on the tobacco cultivation in the district Garoeng [Garung] of the residence Kedoe [Kedu]*).

1911-1.[4] Geschiedenis der katoencultuur in Palembang. Soerabaia, Fuhri. 8 pp. (*History of cotton cultivation in Palembang*). Also in Anonymus: Verslag van het vezelcongres gehouden te Soerabaia van 3 tot 8 juli 1911. Volume I.2: 261-267.

1911-2.[5] Overzicht van de proefnemingen in het belang der Katoen-cultuur in de residentie Palembang van Regeeringswege genomen, benevens voorstellen tot verder voortzetting der proefnemingen. Nota. 19 pp. Buitenzorg, s.n. (*Overview of the experiments on cotton growing in the residence Palembang … with proposals for the further continuation of the experiments*). Also in Anonymus: Verslag van het vezelcongres gehouden te Soerabaia van 3 tot 8 juli 1911. Volume I.2: 271-287.

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1912-1***.[6] Verslag van het onderzoek in 1911 naar de ziekten en plagen der Katoen in de residentie Palembang, de stand der Katoencultuur in Djambi, proefnemingen in Benkoelen en in het Oosten van den Archipel.[7] (Nieuws van den Dag voor Nederlandsch-Indië 13 juli 1912). (*Report of the research in 1911 on diseases and pests of cottonin Djambi [Jambi] …*).

1913-1***. Dure rijst. Tijdschrift voor het binnenlandsch bestuur 45: 353-371.[8] (*Expensive rice*).

1914-1. De organisatie van het Departement van Landbouw, Nijverheid en Handel in Nederlandsch-Indië in 1913. De Indische Gids mei 36: 656-672. (*The organisation of the Department of Agriculture, Industry and Trade in the Dutch East-Indies*).

1914-2. Zaadtuinen voor inlandsche gewassen. Teysmannia 24: 122-151. (*Seed gardens for indigenous crops*).

1914-3**. Overzicht van hetgeen werd verricht ter bevordering van de katoencultuur in Nederlandsch-Oost-Indië. Teysmannia 24: 411-414. (*Overview of what has been done to promote the cotton cultivation in the Dutch East Inides*).

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1915-2. Kolonisatie op de buitenbezittingen. Teysmannia 26: 400-422. (*Colonisation in the outer possessions*).

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1916-2***. De rijstteelt in de laaglanden der residentie Djambi. Tijdschrift voor het binnenlandsch bestuur 51: 259-276. (*The rice cultivation in the lowlands of de residence Djambi [Jambi]*).

1916-3**.** De rijstteelt in Nederlandsch-Indië. Onze koloniën, series 2 no. 8: 1-46. (*Rice growing in the Dutch Indies*).

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Notes

Preface

1 See Annex 4: 1896-1. Earlier reports: 1893-4 and 1894-2.
2 Raciborski, 1913.
3 This is the first formal Dutch paper known to me that explicitly focussed on epidemiology, with the word 'epidemiology' in its title. The printed 1931 lecture did not appear in a formal journal.
4 For the life and work of Thung I refer to Kerling (1961) and van der Want (1961).

Chapter 1

1 '*Sultan*' (Arabic: = prince) and '*Susuhunan*' (Javanese: = emperor), titles of the princes of Jogjakarta and Surakarta, respectively.
2 For Indonesian terms see Annex 3. In this book I use either English or Dutch spelling of local terms and geographical names. The current Indonesian spelling is given in Annexes 2 and 3.
3 Coolhaas (1948) p 8.
4 Today the world has over 4 million hectares of tobacco.
5 The name of the river is not mentioned; there are many rivers in the Klaten area.
6 Textbook, i.a. Jensen (1920).
7 Around 1890 petroleum was found in the south-east. Tin was found on some of the smaller islands east of Sumatra. At the beginning of the 20th century large rubber plantations were laid out in the lowlands. Today, the island is well known for its many oil palm plantations.
8 The NV Deli My (Deli Company Ltd) exploited 70,000 ha in 1879 and 180,000 ha in 1920 (Breman, 1987 p 55). The total exploited area around 1920 was estimated at 240,000 ha, of which 7 % (~17,000 ha) actually under tobacco (Breman, 1987 p 53).
9 Breman (1987) p 3.
10 From the report by J.L.T. Rhemrev, p 345, in Breman (1987) pp 311-408.
11 At the time, nematology was a science still 'in the making'; van Breda de Haan contributed by describing a tobacco nematode (1896, 1899) and a rice nematode (1901).
12 Breman (1987) p 50.

Chapter 2

1 Prodromus Florae Batavae, 1901. Nijmegen, MacDonald. p xxi.
2 Went (1915) p 22.
3 Shew & Lucas (1991) p 18.
4 Zadoks & Koster (1976) p 42.
5 This point had been taken up by Raciborski (1913),
6 Van Breda de Haan (1894-2) p 48.
7 Sundanese is the language of a large part of West Java, bordering Strait Sunda.
8 The Wageningen Agricultural Univeristy was recently re-baptized WUR, Wageningen University and Research Centre.
9 '1925. The subtitle *An international journal* is added by the *Phytopathology* journal. H.M. Quanjer of Wageningen, Holland, was the first editor for Europe, but the editor position was discontinued in 1943.' www.apsnet.org/design-test/history/Documents/1919-1928panel.pdf.
10 Van der Want (1961).
11 Detailed information is to be found in his son's book (Thung, 2004), more specifically in the chapters 7 and 8.
12 Professor Paul J. Thung, the son, provided much valuable information. During a few years I met with professor Thung incidentally as we worked in neighbouring laboratories. He was a charming personality.
13 Professor Westerdijk, see Zadoks & van Bruggen (2008).
14 'Tijdschrift over Plantenziekten', later 'Netherlands Journal of Plant Disease', presently 'European Journal of Plant Disease'.

15 This is the first formal Dutch paper known to me that explicitly focussed on epidemiology, with the word 'epidemiology' in its title; I say formal, because Thung gave a lecture in Klaten entitled 'The epidemiology of tobacco diseases' in 1931, printed in Klaten (This volume Chapter 4).
16 This paper was not mentioned by Kerling (1961) in the list of Thung's papers.
17 The '*kroepoek*' disease is a whitefly-transmitted tobacco leaf curl over-seasoning in weeds and occurring mainly along field borders. The word '*kroepoek*' or '*krupuk*' refers to the well-known curly prawn/shrimp crackers.
18 Vanderplank (1960) initiated the modern, quantitative plant disease epidemiology.
19 In the Netherlands up to 1938 nothing was comparable to the long-term agricultural experiment of Broadbalk at the Rothampsted Experimental Station in England (Zadoks, 1993).
20 Thung's mother tongue was Malay, which has no article; that may be reason for his over-conscientious use of the article in Dutch.
21 I thank Mrs Dr. Elske van de Fliert and her husband A. Yogiyono for clarifying some Malay and Javanese words.
22 The words for 'area', 'field', 'plot' and 'site' were used in a somewhat inconsistent way, as reflected in the translation. The Dutch word '*tuin*', rather common in colonial papers, literally means 'garden', but it usually has the meaning of a clearly defined 'plot', or even a plantation, possibly surrounded by a ditch, bund or fence. Thus, Thung wrote of tobacco gardens and of a cane garden.

Chapter 3

1 Van Breda de Haan, J. – 1896. De bibitziekte in de Deli-tabak. Mededeelingen van 's Lands Plantentuin. XV. Batavia, Kolff. 107 pp + plaat.
2 Van Breda de Haan was the first scientist in an environment unfamiliar with and, maybe, even inimical to science. He had to fight established custom, fixed opinions, superstition and haphazard experments.
3 In translation I maintained the original spelling of geographic and other names, which transcribed local names according to Dutch spelling rules. Today, Serdang, Bedagai and Padang are administratively placed together in the Serdang Bedagai Regency, in the province North Sumatra. The district Padang should not be confused with the town Padang on Sumatra's west coast. The present Deli Serdang Regency surrounds the city of Medan. The Langkat Regency lies north and the Simalungun Regency south of Deli Serdang Regency. See Annex 2.
4 *Rapilli* – meant is (Italian) *lapilli*, pyroclastic particles from 2-64 mm.
5 Trachytes = igneous volcanic blocks.
6 *Alang alang* - when the forest is cut this permanent grass appears preventing the re-growth of the forest.
7 In 1898 the author published a paper on this climate change.
8 A '*bouw*', from Malay '*bahu*', measures c. 0.71 ha. ¾ *bouw* corresponds with about 12,000 plants.
9 Mats made of various materials were used to provide shade.
10 Roads were a mess; the private Deli Railway Company opened its first line in 1886 (Breman 1987, p 36).
11 Nearly all labourers or coolies were Chinese, since the locals did not want to work for the wages offered.
12 The island Borneo, presently Kalimantan; note that North-Borneo did not belong to the Dutch East Indies.
13 The term '*wedangan*', meaning 'as boiled', was not used by Thung (Chapter 5) working on Java one generation later.
14 '*Cultuurtuin*', an old-fashioned term not much used in the Dutch East Indies; meant are the Bogor Botanical Gardens (founded 1817, also trial ground for commercial crops) at Buitenzorg, present '*Kebun Raya Bogor*' at Bogor, some 60 km south of Jakarta.
15 This paper refers to tobacco blue mold, *Peronospora tabacina* D.B. Adam, in Australia especially dangerous on the seed beds (McKeen, 1989 pp 1&4).
16 With *lalang* soil is meant soil covered by *alang-alang*; this, however, is not a soil but rather a vegetation type; possibly the author meant the humus-rich peaty soil left over after growing a crop of tobacco.
17 In his 1898 paper the author discussed the climate change due to extensive clear felling of the native forest.
18 At the time the term 'risk' was not yet in use.
19 The author did not use the term 'symptom', writing in Dutch '*verschijnselen*' = phenomena.

20 The word '*wedangan*' is mentioned later in the text.
21 Leaves of first size – tobacconist's term for a certain quality.
22 This paragraph, epidemiologically interesting, consist of rather crooked sentences, difficult to translate.
23 The point is quite important because Deli tobacco was perfect for cover leaves of cigars and made a high price.
24 I don't know about the penalty, possibly a fine in money, sometimes corporal punishment, or just dismissal.
25 'Mucus plug, in present terminology the 'papilla'.
26 A typical sloppy sentence in the Dutch text.
27 The zoöspore has two flagella indeed.
28 *P. nicotianae* also shows a 'delicate, thin-walled vesicle, which quickly ruptures' (Shew & Lucas, 1991 p. 18). Apparently the author's equipment was not good enough to make the short-lived vesicle visible.
29 'Apadrie', a highly unusual word meaning 'fatherlessness'; we might translate it as 'parthenogenesis'.
30 Quoted in German: "*körnig central und eine peripherische wasserhelle Partie*".
31 The idea that the author worked with impure cultures, or even with similar but different species, occurred also to himself; the point is elaborated in the following lines.
32 Meant is spatial continuity.
33 It is not clear whether the author has observed the revitalisation of the oöspores under the microscope.
34 In fact, there is a vesicle (Shew & Lucas, 1991 p 18) but the author missed it, supposedly because his equipment was not good enough.
35 *Androng*, unidentified pioneer plant on abandoned tobacco fields.
36 It is not clear if this yeast form (?) actually refers to chlamydospores; it would then be the only reference.
37 'sort'; the Dutch text writes '*soort*' = species, but in horticultural practice often = variety, clone.
38 'Bordeaux mixture'; the author always used the French term '*bouillie Bordelaise*', not the Dutch '*Bordeauxse pap*'.
39 Today we would say 400 experimental plots; the author's term 'experimental field' refers sometimes to a single plot, sometimes to the whole experiment with its 50 plots.
40 6 feet = ~1.83 m.
41 The author wrote '*pulverisator*', a word associated with powder dusting rather than fluid spraying, but evidently a sprayer is meant.
42 The author states twice that the nursery beds measure 3 x 18 feet = 54 square feet or ~5 m2; his 18 here must be an error. A bed width of 3 feet = ~91 cm allows the coolie to pick insects and weeds from both sides without entering the bed.
43 Here, beds of 100 square feet are mentioned whereas the usual size of the beds was 3 x 6 = 18 square feet (p 39 top).
44 Supposedly the 132 mm of the last 8 days was gauged on 3 May.
45 Probably the tobacco ant (Roepke, 1918).
46 No. 6 apparently should be No. 5, the author's mistake.
47 Here, the author writes 'experiment I', but he did not report an experiment II etc.
48 Experiments 7 and 8 were not mentioned here for reasons unknown, possibly poor reporting.
49 'light and air' - note the alliteration in Dutch '*licht en lucht*', an easy slogan to convince obstinate planters.
50 Apparently the author meant that the supervisor should consider the weather before removing the covers.
51 Here the author mentions ½ litre of Bordeaux mixture per bed, elsewhere he prescribes 1 litre per bed; I cannot explain the discrepancy but I opt for 1 litre per bed.
52 Experiment No 5 was omitted here because there was no bibit disease.
53 It is not clear how many estates answered the inquiry of 1894. The numbers quoted vary: 42, 49, 44, 53. Anyhow, the response was quite satisfactory.
54 The second case was not mentioned.
55 The Dutch phrasing of this paragraph is definitely sloppy but the meaning is crystal clear.
56 In other words: the shorter and greener plantlets took on better than the slightly etiolated ones.
57 The text suggests that treated 'fields' alternated with untreated 'fields', each 'field' consisting of several 'nursery beds', in the present context an unusual design. Possibly, 'field' should be read as 'bed'.The author sometimes used the word 'field' where he obviously meant 'nursery bed'.

58 Apparently, the insight gained in 1894 by experimentation and inquiry had been generally applied in 1895.

Chapter 4

1 Thung received his training in phytopathology in a period when researchers were fascinated, if not obsessed, by insect transmission of virus diseases (and Dutch elm disease).

2 This sentence is incorrect. The ordinates of the figures 4.4 – 4.7 show absolute numbers of infected plants.

3 For the mosaic disease the data in column A allow to calculate Vanderplank's *r*, the apparent or logistic infection rate, per planting and per inspection interval. The three inspection intervals of five plantings (tables 4.1- 4.3) yield *r* values per planting varying from 0.037 to 0.152. The mean *r* value of the third interval is about twice the mean values of the two earlier intervals. These results suggest that the epidemic growth is not strictly logistic, and that the epidemic conditions vary considerable between plantings and between intervals.

4 The 'line' does indeed show an increasingly rapid, near-exponential growth of the epidemic but it does not show the suggested focal spread that could have been seen on the maps, if provided.

5 Later, Thung demonstrated that whiteflies transmitted the virus from weeds outside the plantation.

6 Here, Thung 'announces' the study rendered in Chapter 5.

7 The numbers of days along the abscissa cannot be deciphered; maximum number of days taken from Table 4.1.

8 It is not clear what 'averaged' means here, nor why the highest value of 330 is lower than the 450 of the foregoing line. Possibly, planting 1 was more severely infected that the rest of the field.

Chapter 5

1 Thung used the term '*gevaar*' = 'danger'; sometimes translated as 'risk', a term not used by the author.

2 Conclusions were italicized by Thung. The logic of the present sentence is questionable but Thung's concern about a possible loss of resistance is genuine and realistic. Maybe, the message was not welcome to his superiors so that it had to be phrased in a crooked way.

3 *Papaw* = *Carica papaya* L.

4 The experiment was done with sterilized soil; it does not inform us about the growth of the fungus in natural, unsterilized soil.

5 A refrigerator running on electricity was not yet available; the icebox was cooled by ice blocks bought from a central ice manufacturer.

6 Leaves still attached to the plants except, apparently, when tested in Petri dishes.

7 Expressed in flecks per leaf:

very old	fast growing
3.2	1.5
3.7	2.6
8.6	1.9
4.2	2.0 on average.

8 The Dutch '*in de praktijk*' ='in practice', a current term usually meaning 'under normal farming conditions'.

9 *Crotalaria juncea* L., sunn hemp, Indonesian: *orok orok*, a leguminous crop ploughed under as green manure.

10 *Djarak* is here *Ricinus communis* L.

11 See p 153.

12 The Dutch term '*tuin*' = 'garden' was current usage for plot or field; tobacco garden, sugar cane garden, supposedly surrounded by a fence, hedge, dike and/or ditch.

13 8000 *bouw* is about 5680 ha.

14 NL: *riet* = cane = sugar cane = primarily *Saccharum officinarum* L. and its many hybrids.

15 NL: *vezel* = fibre = sisal (*Agava sisalana* Perrine), before World War II an important crop on Java.

16 Hill cultures – mainly coffee and tea, sometimes quinine bark trees (*Cinchona* spp).

17 For the 'leaf method' see section 5.4, p 147 ff..

18 The Dutch term used is '*wisseling*' which is translated as 'alternation'; the rotation scheme of the tobacco estates was based on annual alternation of fields.
19 Dutch '*stalmest*' should be translated as 'cattle manure', but here we write 'manure'. The manure coming from the carabao**.** that most Javanese farmers kept, and eventual chickens and ducks was mixed with plant refuse, i.a. from native tobacco and other plants. I do not know whether human faeces was included.
20 Where I write 'row I' etc. Thung wrote 'column I' though he obviously meant row and not column.
21 At the time, the term 'garden' was common in the area, meaning (small?) field – tobacco garden, cane garden.
22 The native, Javanese tobacco supposedly was of unimproved varieties relatively less susceptible to *lanas*.
23 -
24 Thung suggested that the refuse of the local, Javanese tobacco causes this infection.
25 The context suggests that the 'consent' beds and fields belong to the tobacco estates which allow the local farmers to use them during the tobacco-free period. Apparently these nursery beds, laid out at different points in time, were scattered over the fields in a haphazard way. Thung was not against the 'consent' but wanted to regulate the lay-out of the nursery beds.
26 Apparently Thung believes that the fungus remains actively growing in the manure; this may be true but he disregards the function of eventual chlamydospores.
27 The author states 'before' but supposedly 'earlier' is meant; even so the meaning is not clear.
28 The planted area of the estate was 3.305/0.0059 = 560.269 *bouws* = 397.72 ha. The planted area of this estate being ~400 ha, the size of the estate must have been ~1000 ha (2 alternations + roads, conducts, and buildings).
29 Plant density was 0.442 m^2 per plant, which implies a mean distance between plants of 0.665 m.
30 To a total mortality on the estate of 21.61 % the danger spots contribute a negligible amount of 0.13 %, which implies that the area of the danger spots is very small in relation to the total area planted and/or that the percentage of infection in the danger spots is very low. Thung did not say so explicitly but apparently his recommendation to identify the danger spots and to plant them with resistant varieties was effective.
31 Mededeeling Proefstation voor Vorstenlandsche Tabak No. 74.
32 Thung writes '*gronden*'= 'grounds' or 'soils' with the implication 'plots', 'fields', or 'terrain'. In Dutch the term '*gronden*' (plural) for 'fields' is unusual but not incorrect.
33 Mededeeling Proefstation voor Vorstenlandsche Tabak No. 74.
34 The text says 'infection time', today we would say 'exposure time'.
35 The old method was to apply a slurry of soil or manure to the leaves by means of a brush, a laborious method.
36 The author writes '*voorgaande*'= 'preceding'; its meaning is not clear.
37 Bold by author.
38 Thung omitted the expected addition 'and hence not counted'
39 Djarak leaves are roughly 4 to 40 times more sensitive than tobacco leaves, a great variation.
40 'beds'- tobacco nursery beds.
41 Generally speaking the use of artificial fertilizers seems to have been quite low.
42 The author writes '*dijkjes*' =' dykelets', here translated as 'bunds'.
43 This is the author's English summary.
44 'Swarmspores' from Dutch '*zwermsporen*' = zoöspores.
45 The word 'explosional' is not found in current dictionaries; -probably it is of Thung's own coinage.
46 The method is certainly 'sensible' in the modern sense but obviously the author meant to say 'sensitive'.
47 Med. P.V.T. = Mededeelingen Proefstation voor Vorstenlandsche Tabak (*Communications Experiment Station for Principality Tobacco*).
48 Med. s'Lands Plantentuin (*Communications National Botanical Garden, Buitenzorg*).
49 Med. Land. Hoogeschool = Mededeelingen van de Landbouw Hoogeschool (*Communications of the Agricultural College, Wageningen*).
50 Med. Inst. v. Plantenziekten = Mededeelingen van het Instituut voor Plantenziekten, Buitenzorg. (*Communications of the Institute for Plant Diseases*).
51 Journal 'Landbouw' (= 'Agriculture')

Chapter 6

1 He was i.a. vice-president of the Dutch Society for the Advancement of Industry (*de Nederlandsche Maatschappij ter Bevordering van de Nijverheid*). From the society's Journal 1886, p 228. He died at Haarlem, 22 February 1895.
2 'Vragen van den Dag' -1 January 1902: p 690.
3 'Verslag van den staat der hooge-, middelbare en lagere scholen in het Koninkrijk der Nederlanden' 1891: p 7.
4 '*Koninklijk Instituut voor Taal-, Land- en Volkenkunde*'. Bijdragen tot de taal-, land en volkenkunde van Nederlandsch-Indië -1 January 1888: p civ.
5 The Dutch '*gymnasium*' was a highschool teaching Latin and Greek. De Wekker 48 (3) 3 dd 17 January 1891.
6 '*Gelukkig heeft de faculteit hem hier volkomen gezond verklaard, zodat hij met een gerust hart en ongestraft weer onder de palmen mag wandelen*'. De Sumatra post 17 March 1899.
7 '*belast met het onderzoek van levensvoorwaarden, bouw en ziekten der tropische cultuurgewassen*'. 'Soerabaijasch Handelsblad' 6 January 1900.
8 '*ambtenaar-kruidkundige*'. Soerabaijasch Handelsblad 6 January 1900. 'De Locomotief' 3 September 1900.
9 'De Sumatra Post' 20 May 1899.
10 'De Locomotief' 13 June 1900 mentions surgery by Dr. Koefoed.
11 '*versplintering van het been*'. 'De Locomotief' 1 May 1901.
12 '*Proefstation voor rijst en tweede gewassen*'.
13 '*Aan den chef van de tweede afdeeling van 's Lands Plantentuin te Buitenzorg, Dr. J. van Breda de Haan, is een verlof van 5 maanden verleend voor de bestudeering der rijstcultuur in Italië en Zuid-Frankrijk, alsmede de cultuur van andere graangewassen*'. 'De Sumatra Post' 22 June 1903.
14 *II° Congresso risicolo internazionale*, Mortara, 1/3 October 1903. Mortara is in the Po-valley, Italy, south of Milan. The '*Jardin Colonial*' at Nogent-sur-Marne lay just east of Paris; it was established in 1899 as a *jardin d'essai*, an expermental garden for tropical crops, later called *Jardin tropical de Paris*.
15 '*Inspecteur van den Indischen Landbouw*'. Nieuws van den Dag voor Nederlandsch-Indië 21 December 1904.
16 'Nieuws van den Dag voor Nederlandsch-Indië' 2 October 1906.
17 'Bataviaasch Nieuwsblad' 13 November 1906. 'Jaarboek van het Departement van Landbouw' (1906) p vii.
18 'Bataviaasch Nieuwsblad' 10 en 23 November 1907.
19 'Soerabaijasch Handelsblad' 23 November 1907.
20 'Bataviaasch Nieuwsblad' 31 July 1914.
21 'De Sumatra Post' 27 March 1917.
22 'Bataviaasch Nieuwsblad' 1 December 1916.
23 'Bataviaasch Nieuwsblad' 9 May 1917.
24 '*Heden overleed in de zieken-inrichting Tjikini hier ter stede de inspecteur van den Inlandschen Landbouw, Dr. J. van Breda de Haan*'. The town is Batavia. Personalia: Register for births, marriages and deaths of Haarlem and Leiden, Bureau for Genealogy. He was survived by his wife, mother and brother. Nieuws van den dag voor Nederlandsch-Indië 13 October 1917.
25 'Bataviaasch Nieuwsblad' 16 October 1917, obituary with photograph, the only portrait found. Lovink: '*plichtsgetrouwe ambtenaar*', Koningberger: '*voortreffelijke eigenschappen … welke hem als mensch sierden*'.
26 '*Suikerproefstation West-Java*'. Van Breda de Haan (1892, 1893). Van Breda de Haan, working mainly in Buitenzorg, was employed by the Suikerproefstation West-Java (1886) near Kagok, 15 km from Tegal, Mid-Java, on the northern coast. 'Bataviaasch Nieuwsblad' 16 October 1917.
27 This concern was already expressed in 'Bataviaasch Nieuwsblad' 27 February 1894.
28 E.g. 'De Hollandsche Revue' 24 (1919) (1) p 24.
29 'De Locomotief' 29 June 1895.
30 Dr J.C. Koningsberger (1867-1951) succeeded Treub as the director of the Botanical Garden (1911-1917), became chairman of the '*Volksraad*' (a kind of colonial parliament with an advisory function only) and later Colonial Secretary in the Dutch Cabinet (1926-1929).
31 Went (1915) p 22.
32 'Java-bode' 3 October 1894: '*de plaatsing van een botanist voor het genoemde tabaksonderzoek, voor de tijd van 5 jaar*'.

33 The 'new category' refers to state positions paid by private money. '*den gelukkigen uitslag had, dat deze reeds op 27 February daaraanvolgende zich bereid verklaarde deze eerste der nieuwe categorie van betrekkingen bij 's Lands Plantentuin te aanvaarden*'.

34 '*Koninklijke Paketvaart-Maatschappij*'.

35 'Bataviaasch Nieuwsblad' 27 February 1894.

36 19th century mycologists who published a *nov. spec.* usually named the species after the host plant, a characteristic part of the host plant, or a person (predecessor, teacher, friend).

37 Shew & Lucas (2013/1991).

38 The right number is uncertain; counts vary per item.

39 'De Sumatra Post' 10 March 1906: '*De Mozaiekziekte der Tabak*'. '*VAN BREDA DE HAAN ontdekte in 1899 [1898-3] in het zieke weefsel een bacterie, die hij tevens isoleerde en als het virus der ziekte beschouwde*'. F.T.W. Hunger: '*Untersuchungen und Betrachtungen* über *die Mozaiekkrankheit der Tabakspflanze*' (= 'Studies and considerations on the mosaic disease of the tobaccco plant') in 'Zeitschrift für Pflanzenkrankheiten' 15 (5) (1905). At the time the word 'virus', Latin for poison, was used for 'infectant' and that could also be a bacterium, see e.g. Iwanowski 'On the mosaic disease of the tobacco plant' in 'Zeitschrift für Pflanzenkrankheiten' 13 (1) (1903).

40 E.g. Medan 13 April 1901, 'De Sumatra Post' 10 May 1901.

41 (1901, 1902-2, 1903 -1,2,6,7,8,11,, 1904-1,5,10, 1911-2,3, 1916).

42 'De Locomotief' 2 March 1901.

43 Javanese terms; '*omo mentèk*' is something like 'ghost disease', '*omo bambang*' means 'red disease'; in fact the rice crop discolours from green to orange, but most SE Asiatic languages have no word for orange, hence the word 'red'.

44 'Teysmannia' (1890 - 1922) was edited by scientists of the Botanical Garden and published by Kolff in Batavia.

45 'De Locomotief' 6 March 1902 en 7 June 1902,'*geen* geboorte- *maar een* infectie-*ziekte*'; 'De Sumatra Post' 21 March 1902.

46 'Soerabaijasch Handelsblad' 11 April en 22 August 1903.

47 'De Sumatra Post' 3 June 1903.

48 'Nieuws van den Dag voor Nederlandsch-Indië' 22 December 1913.

49 'Nieuws van den Dag voor Nederlandsch-Indië' 5 May 1911: overview of the experiments with cotton in Palembang, Sumatra. 'Bataviaasch Nieuwsblad' 18 July 1912: the cotton cultivation in Djambi (ZO Sumatra).

50 E.g. Van Setten, D.J.G. – 1911.

51 '*Vereeniging ter Bevordering der Katoencultuur in de Nederlandsche Koloniën*', 'De Sumatra Post' 19 July 1912.

52 'De Sumatra Post' 11 July 1911.

53 'Economisch-Statistische Berichten' 1 May 1918: p 373. '*De inlandsche cultuur (in Palembang) heeft onder de tegenwoordige omstandigheden haar levensvatbaarheid bewezen en is voor de inheemsche bevolking van groot belang*'.

54 'Bataviaasch Nieuwsblad' 10 April 1913.

55 'Bataviaasch Nieuwsblad' 19 July 1912. The tidal sawahs were situated far inland with freshwater tides.

56 'Nieuws van den Dag voor Nederlandsch-Indië' 31 October 1914.

57 'De Sumatra Post' 19 October 1917. No confirmation was found.

58 'Economisch-Statistische Berichten' 1 May 1918: '*te weinig deskundig en te weinig energiek werd aangepakt*'.

59 'Jaarboek van het Departement van Landbouw' (1906) pp xix and xxiii.

60 Congresses of the '*Algemeen Syndicaat van Suikerfabrikanten op Java*'. 'Bataviaasch Nieuwblad' 31 October 1904 and 10 April 1905, 'Nieuws van den Dag voor Nederlandsch-Indië' 31 October 1904.

61 'Bataviaasch Nieuwsblad' 17 October 1904 announced the lecture: 'I*ets over gezonde en zieke peperplanten*'.

62 '*Handboek der cultures in Nederlandsch-Oost-Indië*' ('Handbook of industrial crops in the Dutch East Indies'). Undated letter by van Breda de Haan to Sijthoff's Publishing Cy, Leiden, present in the Leiden University Library, shelfmark SYT A 1903.

63 '*Vereeniging de Ooftteelt*'. Meetings were announced in the newspapers.

64 'Bataviaasch Nieuwsblad' 12 March 1903. Malay *tjankok* means cutting or slip.

65 'Nieuws van den Dag voor Nederlandsch-Indië' 30 July 1917.

66 This is also my own experience in the Netherlands as well as in other continents.

67 ‘*Het is hier echter helaas ook weder gebleken, dat zelfs de beste zorgen en de grootste hulp nog niet in staat zijn om den zwakken bruinen broeder om te tooveren tot een kolonist, die beantwoordt aan de verwachting, die de Regeering koesterde*’, in van Breda de Haan 1915-2 p 411.

68 The Dutch of the time employed the unusual word ‘*voedingsnood*’, literally ‘feed need’.

69 ‘De Locomotief’ of July 8th, 1902, was quite negative about the establishment of an umptieth committee. ‘Nieuws van den Dag voor Nederlandsch-Indië’ 11 July 1902. ‘De Locomotief’ 17 October 1902.

70 ‘De Locomotief’ 23 August 1902.

71 ‘De Ingenieur’ 11 September 1910: p 19.

72 ‘*Verslag over den Waters- en Voedingsnood in de Residentie Semarang, uitgebracht door de Commissie, ingesteld bij Gouvernementsbesluit dd.* 2 July 1902 No. 8. Buitenzorg, Buitenzorgsche Drukkerij 1903. Two volumes. (‘Report on the water and food emergency in the Residence Semarang’).

73 E.g. ‘De Sumatra Post’ 5 June 1903 and even more so ‘Bataviaasch Nieuwsblad’ 25 August 1903.

74 ‘*op verzoek eervol ontslagen als lid der hoofdcommissie, belast met de leiding van een onderzoek naar de oorzaken van de mindere welvaart der inlandsche bevolking op Java en Madoera … onder dankbetuiging*’. ‘Bataviaasch Nieuwsblad’ 11 June 1908. Possibly, he relinquished to free a seat for his future director, H.J. Lovink, mentioned as committee member in the final report.

75 Multatuli (= Eduard Douwes Dekker) - 1860: Max Havelaar, of de Koffieveilingen der Nederlandsche Handel-Maatschappy. Amsterdam, De Ruyter. English edition – 1868: Max Havelaar: or, The coffee auctions of the Dutch trading company. Edinburgh, Edmonston & Douglas.

76 ‘De Ingenieur’ 16 november 1912: p 923.

77 ‘De Ingenieur’ 11 September 1910: p 19.

78 www.resources.huygens.knaw.nl. Lovink (1866-1938) was much praised for his enormous energy, creativity and organizational skills.

79 ‘*Zijn weggaan toch werd door de Nederlandsche boeren weinig minder dan als een nationale ramp beschouwd*’. ‘De Ingenieur’ 16 November 1912, p 923.

80 ‘De Sumatra Post’ 10 May 1918 with criticism, 1 July 1918 with an eulogy.

81 ‘*Indië heeft zich gelukkig te prijzen aan het hoofd van het belangrijke landbouwdepartement een man te hebben, die het vermogen bezit op zijn innerlijk compas den sociaal-economischen koers af te lezen, waarin gestuurd moet worden*’. ‘De Indische Gids’ 37 (1915) 992-994 quotes Mr. M. van Geuns in ‘Soerabaijasch Handelsblad ‘: ‘The first ten years of the department of agriculture’ (‘*De eerste tien jaren van het departement van landbouw*’.

82 ‘*De directeur van landbouw in Indië heeft dus in de eerste plaats zelfkennis te beoefenen; dit wordt niet vergemakkelijkt door den dorst naar “gezagsvolheid”*’, ibidem. Note that ‘*gezagsvolheid*’ is an ironic term invented on the spot.

83 ‘*Elk zijner handelingen is van den natuurlijken aanleg voor reclame doordrongen*’, wrote S. Ritsema van Eck in the ‘Java-Bode’, 9 April 1914: ‘H.J. Lovink and the policy of the department of agriculture’ (‘*H.J. Lovink en het beleid van het departement van landbouw*’), quoted in ‘De Indische Gids’ 36 (1914) 877-880. The officer Ritsema van Eck was punished with one month suspension!

84 ‘Bataviaasch Nieuwsblad’ 6 April 1918, ‘Nieuws van den Dag voor Nederlandsch-Indië’ 11 April 1918.

85 ‘Nieuws van den Dag voor Nederlandsch-Indië’ 11 en 30 April 1918.

86 ‘De Sumatra Post’ 10 May 1918.

87 ‘*Maar als de heer Lovink van wit zegt dat het zwart is, dan blijft het zwart. En dies zit de bevolking thans op zwart zaad*’. ‘Nieuws van den Dag voor Nederlandsch-Indië’ 11 April 1918.

88 ‘*dezen van boven af steeds gesmaaden en stelselmatig achteruit gezetten ambtenaar*’. From ‘De Sumatra Post’ 7 May 1918.

89 ‘Nieuws van den Dag voor Nederlandsch-Indië’ 24 en 30 April 1918.

90 ‘De Sumatra Post’ 4 May 1918.

91 ‘De Sumatra Post’ 7 August 1918.

92 ‘Bataviaasch Nieuwsblad’ 9 February, 27 April and 10 May 1904.

93 ‘*Te koop een span uitstekende Australische Wagenpaarden, ook alleen lopend. Te bevragen bij …*’.

94 ‘Bataviaasch Nieuwblad’ 12 September 1918. ‘Nieuws van den dag voor Nederlandsch-Indië’ 6 November 1920.

95 ‘*Vereeniging tot Bevordering van het Bibliotheek-wezen in Nederlandsch-Indië*’. ‘Bataviaasch Nieuwsblad’ 14 June 1918.

96 ‘De Sumatra Post’ 19 October 1917.

97 Annam is Central Vietnam. At the time, Vietnam was a French colony. I found no evidence that van Breda de Haan actually visited Vietnam.

Epilogue

1 In the British colonies phytopathology was very advanced too, see the book by Edwin J. Butler 'Fungi and disease in plants: an introduction to the diseases of field and plantation crops, especially those of India and the East', 1918, written when he was Imperial Mycologist at the Pusa Agricultural Research Institute, India. The bibliography shows that Butler knew the publications in Dutch from the Dutch East Indies, but he did not mention *Phytophthora nicotianae* which, apparently, was not yet present in India or at least not yet noticed. Butler's 1918 book was at the root of the once famous book by Butler & Jones 'Plant pathology' (1949), which had numerous reprints.

Annexes

1 Also published in 1903 in: Tijdschrift voor het binnenlandsch bestuur 24: 311-327.
2 A parasitic flowering plant of the family Balanophoraceae 'growing on tree roots with an aboveground inflorescence with the overall appearance of a fungus' (Wikipedia).
3 Van Breda de Haan was but one of several authors.
4 Published at the occasion of the Fiber Congress in Soerabaja, 1911, organised by the Agriculture Syndicate of the Dutch Indies.
5 Also as annex to publication 1911-1. Published at the occasion of the Fiber Congress in Soerabaja, 1911, organised by the Agriculture Syndicate of the Dutch Indies.
6 Van Breda de Haan *et al*.
7 Djambi = town in E Sumatra, south of Singapore. Bengkoelen = town in SW Sumatra.
8 Paper discussed in 'Nieuws van den Dag voor Nederlandsch-Indië' of 22 december 1913.

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2014. Frankenfood. Gewasbescherming 45: 125-127.

Jan C. Zadoks - biographic notes

Jan C. Zadoks was born in Amsterdam, 1929. He studied biology at the University of Amsterdam. He graduated in 1957, when he was a research officer at the Institute for Plant Protection Research (IPO-DLO), Wageningen. He received his Ph.D. from the University of Amsterdam in 1961, with honours, on a thesis 'Yellow rust on wheat, studies in epidemiology and physiologic specialization'. He is married, and has four grown-up children and five grandchildren.

In 1961, Jan Zadoks joined the Wageningen Agricultural University. He became full professor of ecological plant pathology in 1969. He served 6 years as the honorary secretary of the Netherlands Phytopathological Society, 2 years as the secretary of the University Curriculum Committee, 3 years as the Dean of the Wageningen Agricultural University, and 2 years as Vice-President + 2 years as President of the Biology Section of the Netherlands Science Foundation (NWO). He served 3 years in the Pesticides Registration Board of The Netherlands. For 10 years he was a member of the Committee on Genetic Modification COGEM ('NGO Release Committee') of The Netherlands, with 5 years as Chair of the Subcommittee on Genetically Modified Plants.

He developed what was possibly the world's first course with practical in 'Plant disease epidemiology' and also courses in 'Aerobiology', 'Crop loss', 'Genetics of resistance' and 'Plant protection and society'. The first course led to Zadoks & Schein's 1979 book 'Epidemiology and plant disease management'. He initiated several (inter)national post-graduate courses on dynamic simulation in crop protection. Several post-graduates spent a sabbatical period with him. He lectured in many countries and presented invitational key-note lectures in various assemblies.

He did research in stripe rust, leaf rust, glume blotch and speckled leaf blotch of wheat. His 1974 scale for growth stages of cereals became UPOV and FAO standard. He developed dynamic simulation in plant disease epidemiology, and initiated the development of the computerised pest and disease warning system EPIPRE for wheat. Later, he was involved in field studies, computer simulations, and mathematical analyses of focus formation in plant disease. He took an interest in the development of 'alternative' agriculture and edited the 1989 booklet 'Development of farming systems, evaluation of the five-year period 1980-1984'. He (co-)authored over 400 papers. He supervised over 40 Ph.D. theses and he served repeatedly as an overseas external examiner.

Jan Zadoks had a strong interest in international agriculture. He founded the 'European and Mediterranean Cereal Rusts Foundation' in 1969. He performed consultancy missions overseas for FAO and the Netherlands and French governments (crop loss, resistance, IPM, teaching). He was a Scientific Councillor to the French overseas research organisations ORSTOM in France and IIRSDA in Ivory Coast. He participated in quinquennial reviews of DFPV, ICRISAT, IRHO, IPO, IRRI and ITC. For 14 years, he was a member of the FAO/UNEP Panel of Experts for Integrated Pest Control. He was a visiting professor of the University of Paris, France, organised the XIIIth International Plant Protection Congress, 1995, The Netherlands, and retired in 1994.

Honours: 'Adventurers in Agricultural Science Award of Distinction', Washington (1979); two Dutch Royal Awards for Public Merit (Officer in the 'Order of Orange Nassau', 1980; Knight in the 'Order of the Netherlands Lion', 1993); 'Fellow' of the American Phytopathological Society (1994). Biannual Award of the Royal Netherlands Phytopathological Society (2002); 'Honorary Doctorate' in agriculture from the Swedish Agricultural University (2005); Honorary Life Membership of the International Asssociation of Plant Protection Societies (2012).

Acknowledgements

The Crop Protection Departments of the Wageningen Agricultural College had a sectorial library with a hidden corner full of old stuff. The enthusiastic librarian, Govert de Bruijn, who disciplined a pile of rubble trash thus making a multitude of old papers accessible, passed away. The sectorial library is gone, its contents absorbed by the beautiful and efficient library of what became the Wageningen Agricultural University and later Wageningen University and Research (WUR), sacrificing its *epitheton ornans* 'agricultural' to modernity. In that hidden corner I hit on Thung's 1938 paper, some forty or fifty years ago, and I was enthralled. Then I forgot.

After retirement I remembered the existence of that paper. Deeming it worthy to be known by posterity, I tried to translate the paper. The historical trail led me back to van Breda de Haan's original research on the seedling or bibit disease of tobacco, and causing black shank in maturing crops. I skipped several other Dutch studies on this tobacco disease but, being an epidemiologist, I considered Thung's 1931 lecture too interesting to leave it out.

The 'special collections' departments in the university libraries of Amsterdam, Leiden and Wageningen rendered invaluable services. They provide the physical atmosphere where one feels at ease, a timeless atmosphere where the curious process of de-hurrying takes possession of you. They create a mental atmosphere in which thoughts may drift away, meet with memories, merge with other thoughts, and settle down on the keyboard of your laptop. No disturbance by rattling typewriters anymore, just silence, stimulating, productive. Thanks.

The excellent retrieval system 'Delpher' of the Royal Library in the Hague opened all old newspapers to the inquisitive reader wanting to pry into the life of Dr van Breda de Haan. The Royal Library also provided the picture of van Breda de Haan. Professor Just Vlak sent me the photo of T.H. Thung.

Several photos, that give this book some colour, date from 1979 when Dr Charly E. Main introduced me to tobacco diseases in North Carolina, USA. Mrs Coos van Heuven went through several chapters, critical and constructive, marking every inconsistency with her red ballpoint and finding many typos. Professor Paul J. Thung contributed valuable information about his father T.H. Thung. Dr. Elske van de Fliert and her husband A. Yogiyono helped me to translate Malay and Javanese words.

The prompt services of the publisher, Sidestone at Leiden, are much appreciated.

BLACK SHANK OF TOBACCO

Jacob van Breda de Haan is known as the author of the name *Phytophthora nicotianae* n.sp., the causal agent of 'black shank', an important disease of tobacco. Who was he? Where did he work? What did he publish? He published in Dutch, 1896, in a Dutch colonial report series. Next question: what more on tobacco diseases was written in obscure, colonial Dutch documents? Another scientist, Thung Tjeng Hiang, better known as the first Wageningen professor of plant virology, presented two original papers in Dutch on 'black shank' with the word '*epidemiologie*' in their title, 1931 and 1938. Therewith Thung was an early bird in plant disease epidemiology.

The foundational paper by van Breda de Haan and two important papers by Thung are presented here in English translation. Both authors worked in the former Dutch East Indies, present Indonesia, the first on the island of Sumatera, the latter on that of Java. Both were in the service of tobacco planters; they had to solve immediate problems as fast as possible. In a pioneer situation, van Breda de Haan was confronted with a sudden seedling disease which devastated the tobacco seedlings in the seed beds and which, yes, could lead to 'black shank' in adult plants. Thung, working in a well-organized environment, had to prevent 'black shank' in the tobacco plantations.

Both authors were successful in controlling disease by means of a combination of ecological intervention and chemical treatment. Whereas van Breda de Haan could only dream of genetic control, Thung could incorporate the use of a fairly resistant cultivar in his recommendations. The 1896 paper has epidemiological observations scattered throughout, without using the word epidemiology. The 1931 and 1938 papers are probably 'firsts' in the Dutch phytopathological literature having epidemiology in their title, one an early study in quantitative, comparative epidemiology and the other an early version of landscape epidemiology.

The three papers are preceded by a sketch of tobacco cultivation in the former Dutch East Indies, describing the position of the two authors in the tobacco scene; they are followed by a long-due biography of a forgotten plant pathologist, Jacob van Breda de Haan.

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