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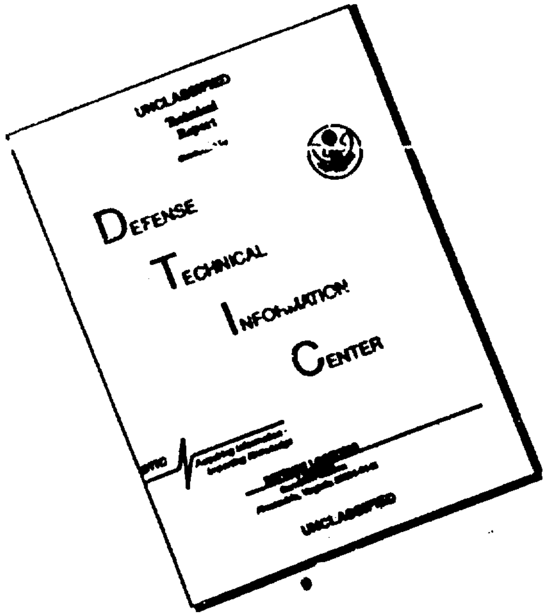

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BACTERIAL DISEASES OF PLANTS

Prof. M. V. Gorlenko, Moscow, 1953

Chapter I

Short Historical Information

Discovery of the world of invisible creatures is linked with the name Leuenguk (Leeuwenhoek?) who in 1683 gave a representation and description of bacteria. Scientists first occupied themselves only with the study of the types and microorganic structures of them. This period of microbiological advance may be characterized as morphological. During this time facts were gathered with no regard for explanation or systematization. The bacterial systematic situation remained vague. Linnaeus classified them with the animal species, in the worm family. Only in 1852 were bacteria classified in the plant group. They were first placed in a group with water plants, and at one point were even considered a stage in mushroom development. Pasteur's research in the fields of medicine, agriculture and technology set the foundation for development of the second period of microbiology - physiological.

The work of Pasteur and his contemporaries, including the academician, N. F. Gamal, was devoted to microbial cell physiology, its biochemistry. At this time microorganisms were artificially bred in solutions of nutritive media. This method did not result in clearly separate cultures. The use of agar for bacterial cultures was first suggested in 1880. Later a method was worked out to separate pure cultures from dense experimental media. The work of a series of scientists proved that the microorganism may only be considered virulent following a certain pathological process where the presence of a given microbe is proven in cases of disease, it is isolated into a sterile culture, an experimental disease is then artificially caused by the isolated bacteria in sterile culture and the bacteria is again isolated from the artificially infected organism.

This rule concerned both bacteria, pathogenic to living organisms and to plants in the phytopathologic field. The same principal was employed during 30 years of the past century to explain plant diseases. The diseased state of plants was considered a deviation from the normal physiological state. A classification of plant diseases and a number of other questions was worked out. The first data on the pathological changes in plants caused by bacteria was recorded by M. S. Voronin in 1866. Studying the formation of tubers on the roots of bean plants, he expressed the thought of possible plant parasitical bacteria. Among the first bacterial plant diseases studied were wet rot, or "yellow disease" of the hyacinth (1886), the pear blossom blight (1889), withering of the pumpkin (1895).

The ability of bacteria to cause plant diseases was questioned at first. This caused a certain difficulty in the study of bacteriosis. As with everything new in science, study of bacteriosis provoked opposition among the old, conservatively inclined microbiologists and mycologists of the time. Even after numerous works by E. Smith (1854-1927) proving the existence of numerous bacterial plant diseases, Gartig wrote that bacteria had no relationship with the pathological process which takes place in plants. This in his opinion proved the absence of a change system in plants; the absence of nitrogen from the cell membrane, on the basis of which bacteria may develop, and also the sufficient size of these cells, exceeding the bacterial size; and, finally, the storing in plants of humic acid, which seems to promote rot development under the influence of bacteria.

A. Fischer, as early as 1899, discovered that bacteria could penetrate into plants as well as through plants, however, he considered this progress necessarily delayed because of suberic materials. In the latter case he disregarded the fermentative action of bacteria, facilitating their penetration and development in growing material.

However, the study of plant bacteriosis slowly won civic rights. At present bacteriosis research is conducted the world over. It should be noted that at present the center of bacteriosis research has moved to the USSR. Research in this field of plant diseases is conducted on a very large scale and with a collective aim in our country, also giving great attention to the entire question of bacteriosis study.

The first work in Russian phytopathology on plant bacteriosis, its appearance, was conducted by M. S. Voronin, followed by G. A. Nadsan (1889). In 1903 in "The Yearbook of Information on Plant Diseases and Spoilage", published by A. A. Yacmevski, we find information on the existence of bacterial tobacco pockmarks in Russia, bean, turnip and broom grass bacteriosis. During the following years information was published (there) on fruit tree root cancer, bacterial diseases of the tomato, the beet, of fruit trees. In 1915 A. A. Potebni, published the first bacteriosis list circulated throughout Russia.

Until the great October Revolution bacteriosis research was only conducted by individual scientists. Mentionable among these are the works of I. N. Trjebinski on sugar beet bacteriosis, A. I. Lobik on potato bacteriosis, N. A. Semashko and G. N. Dorogin on fruit tree root cancer.

I. L. Serbinov (1872-1925) began work in bacteriosis in 1912, as the first scientist to occupy himself specially with this group of plant diseases in Russia. Servinov's scientific activity became especially fruitful after the

Great October Revolution. Besides research in the area of bacteriosis, in a number of cases new to science, he wrote the first comprehensive work on this disease and worked out its method of study. Of the greatest importance among these are data on potato bacteriosis (1915), seed bacteriosis (1922), blending infectious (1925) and others.

A. A. Yachevski (1869-1932) had a great influence on bacteriosis study. Important plant bacteriosis research took place in our country influenced both by his work and his personal guidance. His contribution consisted in elaborating and completing a number of general questions of bacteriosis research, such as the change of the bacteriophage, geographical spreading, the evolution of their parasites and a number of others. A. A. Yachevski's published volume "Plant Bacteriosis" is unequalled in world literature.

V. I. Vscrov (1901-1941) and V. P. Izrailsky (born 1887) began work in bacteriosis at the end of the 20's and beginning of the 30's. The former had the merit of publishing a detailed list of plant diseases common to the USSR (1938). The second was first in the USSR to study the appearance of bacteriophages among phytopathogenic bacteria, and because of this did a great deal of work on bacteriosis diagnosis. Of especially great merit was his working out the serological method of diagnosis in this disease group. V. I. Vscrov and V. P. Izrailsky organized the first laboratories in the USSR for study of plant bacteriosis. A number of scientists have come from these laboratories, devoting themselves to the study of a number of disease groups of importance. Among the pupils of V. I. Vscrov are R. M. Galachyan, O. P. Viktorov, Z. M. Manfanovski. Among V. P. Izrailsky's students - Z. S. Artemiev.

In 1928 reconstruction of USSR village properties was begun on a new, socialistic basis. In connection with the large questions resulting from the developing socialistic village properties concerning phytopathology, the work in bacteriosis research was widened. The study of this disease group was conducted from then on in special laboratories distributed throughout various cities of the Soviet Union (Moscow, Leningrad, Kiev, Erevan). In these the general study of bacteriosis is developed and separate diseases within this group are studied. Each laboratory has a definite aim, which insures a complete analysis of the question at hand.

Nearly all we know today on plant bacteriosis was learned after the October Revolution because of basic research conducted after the beginning of the reconstruction of village properties on a socialistic foundation. Of sufficient proof is the fact that out of 400 works on plant bacteriosis published in Russian until 1947, 25 belong to the period before 1917, 35 to 1917-1930, and 340 to the 1930-1947 period.

At present, the general questions of plant bacteriosis study have been widely analyzed: diagnostic, geographical spread, partly the appearance of bacteriophages and antagonism. The most fully studied sections of bacteriosis are cotton-plant "gommos", bacteriosis of tobacco, cereals, tomatoes, cucumbers, melons, potatoes, white beans. There are well tested, effective means of fighting all these diseases.

Chapter 10 - Methods of Fighting Bacterioses

In organizing and conducting methods of fighting bacterial plant diseases we must bear in mind, that their causes are far from silimar in their parasitical qualities.

A large group of bacteria exists which continually appear on the soil surface or on seeds and the green sections of plants and during this period may cause plant disease. Types such as Bac. mesentericus vulgatus, Clostr. macerans, and a few others. Infection of plants by this group of bacteria results in cases, where they (the plants) are in a weak state because of faulty care, undernourishment, unfavorable meteorological conditions. For example, in cases of great humidity in the air the vascular "coc-sagiza" bacteriosis appears in sharp shapes and infection often ends in the plants' death. Lack of oxygen in the soil will often lead to an outbreak of flax bacteriosis.

The main duty in a fight with this type of bacteriosis is to either remove the conditions causing the appearance of the disease, or placing the plants under conditions, increasing its resistance to disease.

Very many causes of bacteriosis appear more or less linked with plants parasites, who are able to survive both on live plants or feed only on the plant remains. Now with help by agrarian methods we may not always be able to eliminate the beginning of a disease, but we can keep its growth and harm down to a minimum. However, besides this, it is imperitive to know the character of these developments in their natural conditions so as to correctly organise the fight against such plant parasites.

The fact is that the causes of every plant disease under natural conditions has peculiarities, often extremely complicated development characteristics. An idea of these development characteristics may be found in data received as a result of biological bacterial characteristics study in their relationship to surrounding conditions. Causal development characteristics may change depending on outside influences even concerning one and the same bacteria type. For instance, the agent of cabbage mucous bacteriosis (Bact. eroideae and Bact. carotovorum) may suspend its development in nature for a year in case of a hot and damp summer. In this same agent development may last for two years in an area with cooler summers.

It is evident from the figure on p.79, that this bacteria's development cycle may be very short. In Spring the plant (cabbage of the first year) is contaminated by remains of diseased plants having weathered the winter, and in turn rots, and again turns into remains of diseased plants. After this the disease may be spread to healthy plants by wind, rain, human beings or insects, again causing an epidemic. This process may be noticed in the Soutnern region, in the North it occurs during years with hot summers. If the summer is cool this rotting process is slowed up. Disease may spread imperceptibly in cases where the interior of the plant is affected. In cases where such plants are used for seed, the centers will rot while seeking nutriment. During the nutritive period the rot does not develop, as the temperature is not appropriate for this. However, the rotting process is strengthened within, then when transplanted to the field in higher temperature and finally in the end they perish. Thus two years pass from the moment of plant infection to its end and the bacterial entrance into the soil with the plant remains.

The rotation of the cucumber bacteriosis agent (Ps lachrymans) follows two patterns. On the one hand, the bacteria may be in the seed during the winter, thus affecting the germ, the contamination spreads to the leaves, and finally to the fruit and again to the seed. On the other hand bacteria may remain in diseased plant refuse on the soil surface, thus affect the leaves or the fruit and again remain in the refuse or the seed during the next winter.

Sometimes bacteria follow a very complicated path until they reach the section of a plant in which they can develop. For instance, the agent of ring-like potato rot (Mycobact sepedonicum) before entering the plant vessels, appears on the pitted surface of rotten tubers. Soon the pits on the tuber surface deepen, developing into vascular rings. Bacteria from these original foci of rot spread in the rings and later planting of such tubers causes wilting of the plants.

Bacteria may enter sown healthy tubers by a simpler manner through cuts in the seed material. In this connection it has been established that after cutting a diseased tuber the knife contains enough bacteria to contaminate 10 tubers. Finally, these bacteria may spread with delay.

The mentioned examples show how varied and at once complicated may be the development characteristics of bacteriosis agents in nature.

Certain types of bacteria contain principal and secondary causes of plant disease. For example, in the plan of development of the mucous bacteriosis agent, the main cause of disease in cabbage during the first year is caused by rotting remnants of diseased plants, while for second year cabbages it is caused by cabbage heads with rotten centers.

The main cause of cucumber bacteriosis may be found in the seed. Besides, this secondary contamination may arise from diseased plant refuse. The main cause of ring-like potato rot appears in tubers with pit-like rot. All the rest only completes and strengthens this main cause.

Discovery of all details of the development characteristics of bacteriosis agents in nature is necessary for correct recommendations to fight them. We know the main and secondary infection causes, and also the path of bacterial plant penetration, which usually consists of the weakest, most vulnerable spot which may easily and necessarily break. Correct identification of such elements leads to rapid defeat of the disease.

Corresponding to the existance of principal and secondary disease agents in the phytopathogenic bacterial life cycle are principal and secondary measures for fighting them. Thus, the following basic and secondary methods may be used to fight bacteriosis, development characteristics of which have been described above.

The basic means of fighting mucous cabbage bacteriosis are methods which speed up rot and destruction of plant refuse. To fight seed bacteriosis in the cabbage, spoiled articles are thrown out, such as many heads that are rotten in the center, and a better seed nutrition atmosphere is created.

The principal method of combating cucumber bacteriosis is by disinfection of the seed, secondary precaution - destruction of infected plant refuse.

The main problem in fighting ring-like potato rot is averting formation of pitted rot (autumnal method, connected with sorting and drying of tubers). It is also imperitive to disinfect the knife used to cut seed tubers and to fight contamination.

The following shows what methods of bacteriosis fighting should be included as a major part of the all around system of protection of this or that culture from harm and disease.

Important Methods in Bacteriosis Control.

Methods of seed disinfection. In connection with the fact that many bacterial plant diseases are transmitted through seeds, seed disinfection (treatment with a solution) appears to be one of the most important methods in bacteriosis control. In certain cases the disinfection may be limited to the surface, but the interior sections of the seed must often be rendered harmless, owing to the fact that most bacteriosis agents penetrate deep into the center.

Chemical means to seed disinfection. This method entails treating the seed with various chemical products - bactericides. The following are used this this way for bacteriosis control.

Formalin. This preparation basically appears as a surface disinfectant. Only in cases where it is used to control cotton gum disease does formalin penetrate the seed and the periphery of the germ. However it does not penetrate through the rind but through the so-called hilum aperture. The solution entering the seed slowly penetrates from the periphery to the center. Penetration of the liquid formalin solution results in swelling of the seed, and the speed of solution penetration depends on the time for swelling. Swelling, and therefore formalin solution penetration is very slow in less open types. Warming of the solution speeds up the formalin penetration process in the seed. The formalin change when heated is known as the thermochemical method.

Usually weak water-formalin solutions are employed. Seeds, besides being submerged in solution must necessarily undergo fixation (retention in liquid). During this period basically, the seed is disinfected by accumulation of formalin particles. The weaker the formalin solution the longer fixation must last. Thus in case of a commercial (40%) formalin solution of 1:90 the seed must be fixed for 3 hour., while the fixation period is lengthened to 10 hours in case of a 1:200 formalin solution. Especially effective is passing through warm formalin or its steam.

Soviet scientists have perfected an efficient method of staining cotton seed with formalin. Special departments have been constructed to this end at all cotton processing plants.

Formalin may also be used to disinfect tobacco seed against bacterial-pock (1:50) and tomatoes against bacterial cancer (1:300 and 1:100).

Mercuric chloride. This element has proven to be a good bactericide with the help of which one may disinfect the exterior and partly the interior of the seed. Mercuric chloride is widely used in combatting tomato cancer, cabbage bacteriosis and numerous other diseases. Usually a very light solution of this element is employed, 1 part mercuric chloride to 1000 parts water (for cabbage and cucumber seeds), 1 to 3000 parts (for tomato seeds). Seeds are immersed in such a liquid for 5 minutes, then rinsed in water 5 to 10 times and may be planted after drying.

Mercuric chloride is a powerful poison. Because of this, work with this element mus t be conducted according to special instructions.

NIUIF-1 compound. This compound was proposed by the scientific institute for approval as an insectofungicide from which it has derived its name. The compound consists of a type of ethylmercurophosphate solution. A 1.3% solution of this compound is usually sold, which is known as the master solution. Working solutions are prepared for use from the master soltuion according to circumstantial need. The NIUIF-1 compound is used for treatment of cucumber and cabbage seeds against bacterial disease. A working solution is prepared from the principal solution by diluting one part of the latter in 300 parts water for cucumbers and 1 part to 400 parts water for cabbage. This compound positively disinfects both the exterior and interior sections of the seed. The compound is very poisonous and therefore must be handled with the utmost care. A treated grain is harmful to human and animal digestion and may only be used as seed grain. At present a dry NIUIF-1 compound has been produced which with the NIUIF-2 is gaining in popularity.

NIUIF-2 compound. (granular) represents a dust conglomeration, formed by 2-2.5 parts ethylmercurochloride or ethylmercurobromide (active element) and 97.5-98 parts talcum (neutral element). Seeds may be treated with NIUIF-2 in machines for seed disinfection against smut. It is adapted to cucumber bacteriosis, cotton gum, soya bean and bean bacteriosis. It is recommended that this and the former compounds be employed centrally when immersing cucumber seeds, by disinfecting seeds at the sorting point. Disinfected seeds marked with labels are then issued to the consumer.

Concentrated sulfuric acid is used in treating cotton seed against gum. For 10 kg of Egyptian cotton seed 1,5-2,3 kg sulfuric acid is needed, while 2-2,3 kg are needed for American seed. It moistens the seed, by continual mixing for 30-60 m. with a wooden spade, until complete disintegration of the flower. The seed is then washed for 15 m. in a great quantity of running water. Then is dried and planted after presowing preparations.

Physical means of disinfecting seed using hot water. It is recommended in disinfecting colored cabbage seed against bacteriosis. Seeds are kept at a temperature of 50°C for 20 m.

Biological means of disinfection seeds. The following may be stated:

Treatment of the seed with bacteriophages. Treatment of cotton seed with bacteriophages is a possible means of treatment during vernalization. According to O. P. Lebedev this prevents cotton seed and stem gum and increases plant resistance.

Phytocide treatment. Bactericides, protistocides, and fungicide elements produced by higher and lower plant types are known as phytocides. These elements were discovered by Prof. B. P. Tokin (?) in 1928.

The experiments of G. A. Harkin showed that the garlic phytocide arrests growth and development of phytopathogenous bacteria, Bact. aroideae, Bact. carotovorum, Bact. phytophthorum, Ps. vesicatoria, Ps. malvacearum, Ps. citriputeale (fig. 10) Ps. atrojaciens, Ps. heterocea.

This permits the use of garlic phytocides in disinfecting seed and seed material from a number of bacteria. It has been practically possible to produce garlic powder for cabbage seed protection against vascular bacteriosis, and to protect stored potatoes against rot.

The nonharmful quality of phytocides for man and plants allows one to consider this method of seed disinfection in a larger perspective, based on research in the near future.

Fermentation of tomato pulp applied to certain seeds. This product is used in the fight against bacterial cancer. The very process of seed disinfection aided by this method stems from protracted tomato pulp fermentation (for ten days). Seed completely devoid of cancer was obtained after such a process even in cases of high original infection. As a result, farms are delivered of trouble by seed treatment and in special cases by drying during the spring field working season.

Disinfection of young trees and buds. This action directs the fight towards spread of disease instead of concentrating on seed material. Plant disinfection in fruit trees changes into a fight against bacterial root cancer, and immunization of the citrus bud against necrosis.

The following products are employed in disinfecting fruit trees:

a. Soaking for 5 m. in a 1% copper sulfate solution and then rinsing off with running water.

b. Soaking in a 5% copper sulphate solution with equal quantities of clay and sand (cream-like consistance) without further rinsing.

A formalin solution (1:300) is recommended in disinfecting citrus buds; they should be exposed to this for 5 m., or silver nitrate (1:1000) keeping the bud in solution from 1 to 5 m.

Soil disinfection. This field aims at soil immunization against phyto-pathogenous bacteria found here instead of in plant refuse. The disinfection of hotbed soils is of great importance in fighting bacterial tomato cancer, vascular cabbage bacteriosis and a number of other bacterioses, affecting the hothouse and hotbed seedlings.

Chloropicrin has proven to be the best soil disinfectant. It is applied at the rate of 60 g, or 36 cm^3 to 1 m^2 of soil in 20 cm layers. Work with chloropicrin should be conducted during cool, overcast weather, as a slower evaporation of the product from the soil takes place at such a time. The soil should be aired after such disinfection to eliminate the chloropicrin.

Formalin is also used to disinfect sheltered land. For this purpose it is diluted in water at a rate of 1:40 or 1:70. 10-15 or 15-25 liters of this solution may be used on 1 m^2. Formalin is also used to disinfect soil against fruit tree root cancer. In this case 65 g. of formalin are necessary to every sq. meter. Formalin soil disinfection is done in Spring and Autumn. After formalin spraying the soil should be mulched and hotbeds covered. The soil is uncovered after 1-2 days and carefully spaded so as to air out the formalin. Such soil may be seeded 10-15 days after disinfection.

Destruction of infection on sick plant remains. This may be done in two ways. Plant refuse which is hard to rot must be collected and destroyed. They may be used as fuel (for example cotton stalks), collected in the fields, placed near the home and used until sprouts appear. The destruction of cabbage heads is of great importance to the fight against vascular bacteriosis, and cotton stalks in gomosis fight.

Easily rotting refuse may be spaded into the ground in autumn. They usually rot by spring and pathogenous bacteria die. This is known for cucumber bacteriosis, cotton gomosis, and vascular cabbage bacteriosis. So as to complete this it is best to use a plow with a pre-plow (?) thus completely turning over the ground. See Ch. VII for explanations of this process.

Importance of grasses and other rotative crops in the fight against plant bacteriosis. The basic importance of rotation in the bacteriosis battle is cleaning the soil of infection. For a successful completion of this aim in the fight against bacteria-monophagous rotation must seek to destroy deceased plant refuse. In case the fight is with polyphagous bacteria it is important that the culture be so arranged as not to give the bacteria a chance to develop. For instance it has been demonstrated that the agent of cabbage vascular bacteriosis attack numerous plants. The garden beet and cereals are immune to this agent. It therefore follows that these plants should be planted to rotate in an area which has been strongly affected by vascular bacteriosis.

Grass rotation plays an especially important role in fighting bacteriosis. Acad. B. P. Williams believes that the main quality of soil planted with perennial grasses, "this frees the soil of a great number of microzooparasites", and this takes place because the microorganisms living in the soil "the microorganisms feed principally on the bacteria".

Research conducted in Cossack cotton-alfalfa experimental stations, has shown that cotton-alfalfa rotation considerably diminishes the ravages of cotton gomosis. This stems from two facts, on the one hand a quantity of autogomistic microflowers are produced during a 3 year alfalfa growth, which kills the gomosis agent, on the other, during this same time organic matters gather in the soil, the soil structure rebuilds and improves, resulting in more nutritive qualities. This leads to a type of cotton hardier against gomosis.

The virulence of plant root cancer (Ps. tumejaciens) in the soil rapidly drops to a considerable extent through the microbe's residence in the soil without the symbiosis of the natural environment.

Cutting out of affected parts and separation of diseased plants. Cutting out of affected parts appears as the most important action in the fight against tree bacteriosis. Usually they not only cut the affected area but also a section of healtny material. I suppose that this is done because the bacteria have already entered the healthy section but have not yet caused visible damage. This activity is of importance in the mulberry tree bacteriosis, fruit tree bacteriosis, citrus necrosis and similar illnesses.

In case of root cancer damages when transplanting young trees at fruit tree nurseries it is recommended to cut out affected parts and to follow this with disinfection of the root system. Such disinfection is described on Page 85.

Young plants which are diseased around the root crown or on the main root should be destroyed.

Destruction of affected plants may also be applied to certain herbaceous plant bacterioses. For instance, it is used when cotton and cucumber shoots are damaged. In this case cotton shoots are destroyed because of gomosis contamination, and cucumber because of bacteriosis contamination.

During large bacteriosis infections, spreading during the summer to growing plants, destruction often does not meet the goal, as more and more new plants keep getting infected.

Destruction of potato plants affected with black lice and ring rot, frees the seed material of infected tubers, carrying the infection to the next year. During culling not only diseased plants should be destroyed but they should be dug up and removed with their tubers.

Fight against insects. Insect fights in many cases may be of great importance in bacteriosis destruction, for many of the latter spread on insects. For instance, in the fight with cabbage vascular bacteriosis one always meets insects destroying the cabbage. As long as those objectives are proposed but no actual insect-destruction takes place, cabbage will suffer from vascular bacteriosis. Thus, in a number of Kolhozes in the Har'kovski region, where insect destruction was conducted alongside other activities against vascular bacteriosis, cabbage infection was cut to a minimum. As long as insect destruction had not been attempted the effectiveness of all other activities was strongly curtailed.

Corn spraying with DDT preserves the cob against breadbug and bacteriosis damage, which appears to be carried by a certain insect.