

INSTITUUT VOOR PHYTOPATHOLOGIE.  
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## STIPPLE-STREAK DISEASE OF POTATO

BY

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### INTRODUCTION.

The potato plant is subject, as is well known, to a number of etiologically little understood infectious diseases as leaf-roll, mosaic, crinkle, etc., all of which cause a gradual or more or less rapid decline or „running-out” of this plant. The infected plants undergo some grossmorphic changes, take on an entirely different external appearance, their size diminishes more or less rapidly with every new generation, their yield does the same, until eventually all of the infected plants fail to form any tubers whatever. No case of recovery is known and it can safely be assumed that every infected plant and its progenies are doomed to death sooner or later. To this group of diseases belongs also the stipple-streak disease of the potato plant.

As is the case with the other plant diseases of same class in general and of the potato in particular, the efforts to throw some light on the nature and cause of this disease have not yielded the expected or rather the needed results. The direct methods of studying the disease have given only very doubtful results, which do not justify their discussion at this time. The little that has been learned regarding the nature of this disease has been learned in an indirect way, as has been the case with practically all plant diseases belonging to same class.

The object of this paper is to describe the disease and to present the information regarding its nature gathered during the last two seasons.

There is an extensive literature on this subject which can

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not be included in this paper, as it covers to some extent some other of the running-out diseases of the potato plant; besides it is entirely of a descriptive nature. In this paper will be considered only the few papers dealing with the nature of the disease <sup>1)</sup>.

In studying this disease the writer has been using chiefly the methods worked out and used by Professor QUANJER in his work on the running-out diseases of potato. His extensive experience and his knowledge of these diseases and of the potato plant have been of unestimable value for the writer in this work.

### THE DISEASE.

#### COMMON NAMES.

The disease here under consideration has been known in the various countries ever since the latter part of the eighteenth and until the end of the nineteenth century as „Krul” or „Kroesziekte”, „Curled tops”, „Curl” or „Leaf-curl”, „Krause” or „Kräuselkrankheit”, „frisolée” or „maladie frisée” and „pirve”. All of these names, except the last, have the same meaning and have been given to this disease by the practical potato growers in the respective countries. It is not possible to establish when and where each of them has been used for the first time, as the disease was known and named by the potato growers before anything of importance was published on this subject. It is, however, known from the earlier literature that all of these names have been used before for designating the peach leaf-curl and related orchard-tree diseases.

In 1897 SORAUER described the primary form of this disease by the name of „Stippfleckenkrankheit”.

In the beginning of the present century this disease, though continuing to be as common and as important as before, disappeared as such and the century-old and well established names began to be used in a more or less indiscriminate way for other or new potato diseases. Almost as soon as the old disease disappeared it began to reappear in all countries as a „new” disease.

APPEL in 1906 gave the name „Bakterienringkrankheit” to

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1) For the rest of the literature see: D. ATANASOFF: A study into the literature on stipple-streak and related diseases of potato. Mededeelingen van de Landbouwhoogeschool te Wageningen. Deel 26, Verhandeling 1. 1922.

this disease in combination with a soft rot producing bacterial disease of the tubers. HORNE called it in 1911 „Leaf blotch”. According to Miss DALE the same disease as seen on the tubers is known in England as „Blindness”. ORTON in 1913 gave the name „Streak” to same disease. APPEL in 1917 called it „Schwarzflecken- und Streifenkrankheit”. GÜSSOW in 1918 applied to it the name „Leaf streak”. MURPHY in 1920 used the name „Leaf drop”.

In Holland this disease as seen on the tubers of the early varieties is known as „Oogenziekte”. For the disease as seen on the plants and before its relation to the former was known Prof. QUANJER has suggested the name „Stippel-streepziekte”, which name has been generally accepted.

All of the new names of this disease have from the stand point of priority no right of existence whatever, and were the old names not so general and inclusive as they are, no one would be justified to use or to give preference to the new names. The old names are, however, so inclusive and unexpressive of the disease, that they are very likely to lead, as in the past, to new misunderstandings, especially among the practical men. The writer feels therefore justified in suggesting that APPEL's „Schwarzflecken- und Streifenkrankheit”, ORTON's „Streak” and QUANJER's „Stippel-streepziekte” be retained as names for this disease in the respective languages, as they are most expressive of the disease and cannot be easily mixed up with any other disease of the potato. MR. FOËX has suggested the name „maladie des raies”, for this disease, though he is of the opinion that the French public will accept the name „Streak” just as well. In view of the fact, however, that there exists another potato disease which has not yet been described and which produces streaks or short irregular stripes on the stems and dropping of the leaves, but does not produce any spots on the latter, it seems desirable to change ORTON's name to „Stipple-streak” in distinction to the „Leaf-drop-streak”, which name has been suggested by Prof. QUANJER and is preserved for the second disease.

#### GEOGRAPHIC DISTRIBUTION.

The distribution of stipple-streak is quite general and it is not unlikely that when we learn to recognize and separate it from the various closely related potato diseases, it will prove to be even more spread and destructive as is now generally thought. It has been seen in various parts of Austria, Germany,

Sweden and Holland. Professor QUANJER saw it in France, Spain and England. It occurs in the United States and Canada. In the United States ORTON reports stipple-streak from Maine, New York, Wisconsin, Washington and Idaho.

#### VARIETAL DISTRIBUTION.

Up to the present Stipple-streak has been seen on a large number of morphologically most different potato varieties. ORTON reports stipple-streak on the varieties Factor, Rural New Yorker and on Sophie x Keeper hybrids Nos 821 and 822. BARRUS saw it on Evergreen; MURPHY on Green Mountain and on the Scott. In Holland stipple-streak has been seen by the writer, and the staff of the Institute and the Phytopathological Service on the following varieties:

|                          |                   |
|--------------------------|-------------------|
| Schotsche Muis (Victory) | Wilson,           |
| Atlanta,                 | Douwe Jan         |
| Koksiaan,                | Paul Krüger,      |
| Duke of York II,         | Kruisling,        |
| Duke of York Nunheim,    | Irish Cobbler,    |
| Non plus ultra,          | Cowhorn,          |
| Early potato,            | Excelsior,        |
| Ninety fold,             | Deodora,          |
| Ash-leaf,                | Thorbecke,        |
| Ringleader,              | Stein,            |
| Juli Muis,               | MacCormick,       |
| Kommandant,              | Zeeuwsche blauwe. |

In the varieties Schotsche Muis, Atlanta, Duke of York II and Early potato, being all of them earlies, stipple-streak had been seen in epidemic form, from 20 to 75 % of the plants being infected. So far in all other varieties the disease has been seen only in sporadic form.

#### ECONOMIC IMPORTANCE.

The approximate losses caused by stipple-streak are difficult to determine, as up to now the disease, because of its resemblance to some of the running-out diseases of potato, has been generally considered as being the one or the other of the latter and has gone unnoticed. APPEL reports that in 1905 in some localities the loss due to stipple-streak reached 30—40 % and that some fields were so heavily infected that it did not pay to harvest them. However, APPEL had to deal with two different diseases,

and it is difficult to surmise what portion of the total loss has been due to stipple-streak.

ORTON states that by August 16 en 17, 1912 a considerable portion of the plants in a field infected with the disease was already dead.

In Netherland and especially in the province of North Holland where the disease appeared on the early varieties in a more or less epidemic form during the spring of 1921, the writer saw cases where before the end of May over 75 % of the plants were already dead or heavily infected, so that the crop so far as these fields are concerned, was a complete failure. Such fields, however, were not common. The percentage of infected plants usually did not exceed 20 % and the loss in yield was much less. This epidemic appearance of the disease shows nevertheless that under certain conditions and in certain years this disease may become of very great economic importance.

#### DESCRIPTION.

No better contribution can be made towards the advancement of the whole question of running-out diseases of the potato plant than by giving an exact and full description of any of these diseases, based upon an intimate and exact knowledge of the disease in its whole development and in all of its phases. This becomes much more important when we consider that there have been and are still prominent and earnest workers, who, while studying some of these diseases, have not known them in pure form and in their whole development or have considered the various stages of the diseases as independent and distinct diseases. Very often it is not possible to understand from the older and more recent literature on these diseases with which particular disease or diseases the authors had to deal.

Stipple-streak in most cases and on most varieties and when in pure form, is a very distinct disease and can hardly be mistaken for any other disease as ORTON first pointed out. In its primary form for instance, we need see only one streak on the leaves in order to become sure that this plant is infected and that in a short time it must die from this disease. Yet nothing is more difficult in some cases and in some varieties than picking a secondary stipple-streak plant out of a number of other plants infected with crinkle or even mosaic. Such cases occur also in the primary form and the best plan is to reject such plants for further studies, as they only make more complicated a problem which is difficult enough as it is.

### A. Primary form.

*a. The vines.* The symptoms of primary stipple-streak vary more or less according to variety. They are more numerous and more pronounced in the early, succulent and light green varieties.

Primary stipple-streak in nature can be seen only on the fully grown plants, though artificially the disease can be transmitted to very young plants as well. The first sign of the disease is the appearance at first of several, afterwards of more uniformly distributed dark brown spots between the veins of the lower or middle leaves of the plant. At first only one single leaf may show these symptoms, or only the leaves of one single shoot; not seldom the leaves of the weakest shoots may first show the signs of infection. The spots have a distinct angular outline, the number of angles varies from three to five and more, but five is the most common number. The spots are usually smaller in diameter, or when elongated shorter, than  $\frac{1}{2}$  cm., they are of uniform texture and color, with sharply defined borders, having same shape and size on both sides of the leaf and standing in the normal green of the leaf, no intermediate region being present. It is only when we look closely or with a lens that we do see a very narrow line of slightly translucent cells between the black spots and the healthy portion of the leaf. In some cases on the early and very succulent varieties or on a very vigorous and succulent plant, there may be seen a grayish white margin around the black spot, which disappears gradually in the surrounding green tissues. The color of the spots, which are slightly sunken, is dark brown to black. The infected plant at this moment is perfectly normal in every other respect, except that the two halves of the leaflets not seldom seem to stand at a smaller angle to each other, than those of the healthy plants. Short time after the appearance of the above spots usually within a few days, if the weather is warm, there will appear black spots on the uppermost leaves or most commonly on the still young and succulent leaves just below the growing point, i.e. in the region of the lower portion of the upper fourth of the plant. Here the spots are at first and usually remain much smaller and more numerous than in the first case. In some cases they can be so numerous and so small that the whole plant appears as if it has been peppered. In such cases the disease resembles closely if not completely one of the forms of crinkle. These spots are not like those on the older leaves more or less rounded, but they are elongated, sometimes resembling more a streak than a spot and usually appear on or near the veins, they then extend over the latter and more or less into all other veins which

they touch. Here too the angular shape is the distinct characteristic of the spots. If we turn up such leaves we shall see that the larger portion of the veins is affected and is dark brown to black in color. The infected plant now, though still having a healthy green color, shows upon careful examination in the shade that its color is not of same density throughout and that it somewhat resembles potato mosaic. An examination of the stem which at first was still normal, may also show some effects of the infection, which is shown by the long dark olivaceous green to brown stripes on them. These stripes are not continuous over the whole stem and may be seen more or less on all sides of the stem, though in some cases they are limited at first only to one side of the stem. In such instances sometimes the striped side of the stem and the spotted leaves on it become so diseased that they die completely while the opposite side continues to grow for some time yet, which causes a distinct bending of the whole shoot towards the infected side. The stripes represent dead or badly affected groups of cells and tissues under the often still normal epidermis and subepidermal layer. Their borders are not sharply defined and they have a watersoaked appearance. The newly infected young leaves soon begin to wilt very rapidly, shrivel up from the top downwards, break off partially and usually remain hanging on the stem, the leaves above them follow in same way and the dying and shriveling up of leaves proceeds rapidly downwards, the oldest leaves dying last. The axils of the petioles of infected leaves are usually striped and blackened. The stripes on the stem increase in length and in area until the whole stem more or less gets affected: the wilting here also proceeds downwards. The wilting of the leaves is a rapid process, so that no apparent discoloration or browning outside of the brown spots takes place.

The infection at first and in some cases for quite a long time may remain restricted to one single shoot, which wilts and dies completely, while the rest of the plant continues to develop perfectly normally and forms normal tubers, though they in some cases, even when formed on stolons of still perfectly healthy shoots, may be already affected, as will be seen later. Usually the disease shows itself in the rest of the shoots, within a comparatively short time and often in two or three weeks, from the appearance of the first signs of the disease, the whole plant dies completely. There is no definite time when the first infections of the disease appear and not in all cases do they appear at the same time. The first cases in Netherland were observed during the second part of May and they did continue appearing, scattered quite uniform-

ly throughout the field, during the whole growing period.

*b. The underground portions of the stem and roots.* If we pull out an infected plant or shoot we shall see that the lower and woody portion of the stem just above the ground is not changed much by the disease, though it may in some cases also show the streaks as seen above. The underground portion of the stem is usually healthy-looking and white-colored, though ruptures and shorter or longer splits are not uncommonly seen on them, but they are not uncommon on the healthy plants either, and it will have to be established yet experimentally whether they can serve as and are the entrance for the pathogen as Appel has suggested. In the roots, small and large, there is apparently no change. If we examine the stolons we shall often see, especially in some of the early varieties, that the stolons are discolored here and there, the discolored or even rotted spots not having directly a brown color, as may be expected, but a watery grayish white one.

*c. The new tubers.* If we dig out with utmost care the tubers of primary infected plants so that the epidermis does not get injured and examine them carefully we shall see, according to the variety, stage of infection and weather conditions, one of several things: 1. That the tubers of some varieties are and remain for all time apparently healthy. 2. All or some of the tubers at the time of digging may be apparently healthy having perfectly healthy and unbroken skin. Yet when kept for some time, usually within two or three weeks or longer, they will show more or less the presence of the disease which increases as time passes. 3. In other cases the tubers will show distinct pathologic effects. These effects are always external and can be of two kinds, according to the variety and very likely according to the weather and soil conditions under which the plants have been grown. The weather or rather the moisture seems to influence differently the symptoms on the tubers in the different varieties.

If we examine carefully dug out tubers of infected plants of the variety Schotsche Muis we shall see that all, or at least some of them, show on the surface distinct and quite pronounced blisters, resembling somewhat the blisters we get on our hands from burns or from hard work, they are quite sharply defined and are irregularly spread more or less over the whole tuber, in the case of young tubers and more in the neighbourhood of and on the eyes in the more mature tubers, also on the stem-end of the tubers. Quite often these blisters appear just under the



lenticells but they are also seen away from lenticells. These blisters can reach sometimes a height of one or two millimeters, usually they are less than one millimeter in height. Soon after their appearance they begin to shrink, the affected tissues die, dry up and are drawn back, beginning from the centre of the blister, so that while the centre of the blister dries up and is drawn in, the edges remain elevated and continue to advance over the rest of the surrounding area until the whole surface of the tuber may get covered by the extending blisters. If the tuber is still growing and increasing in size the dead portion of the blister splits in one or several directions. This splitting is the result of the rapid development of the healthy portion of the tuber under the infected and dead portion of same. It is the pressure exerted from within that causes the splitting of the dead outer cortex and underlying layers of cells, and the more rapid the development of the tuber inside and underneath the infected area the deeper the rupture will be, until in some cases it can go so far as to cut completely the whole tuber in two or more pieces. This is a phenomenon often observed on scabby fruits especially on peach fruits attacked by *Cladosporium carpophilum*.

In less severe cases and in older tubers the blistered and affected areas usually do not break open and continue to increase more or less rapidly in area even after harvesting of the crop, and during the whole winter, so that tubers which when harvested may be perfectly healthy develop the typical symptoms of the diseases later in storage. In the more mature tubers the disease shows itself usually on and around the eyes, usually beginning from the „eye brow” and often remain restricted only over the area immediately around the eyes, hence the name „blindness” and „eye disease” as applied to this form of the disease in England and the Netherlands respectively. Besides the eyes the stem-end of the tubers is also commonly affected. In all cases the affected area dries up later, becomes cinnamon brown in color and has a quite sharply defined border line.

Mr. de Jong of the Phytopathological Service had planted twenty or more tubers of the variety Schotsche Muis with pronounced symptoms of stipple-streak, all of which gave typically secondary stipple-streak plants, yet their tubers did show only very slight effects of the disease, as are sometimes seen on the variety Paul Krüger, and were too large for plants with secondary stipple-streak. This exception out of an unlimited number of cases cannot be explained in any way and it represents an interesting subject for further observations.

The pronounced affection on the tubers as described above and as commonly seen on the variety *Schotsche Muis* is not at all so pronounced in all varieties and may be quite absent in others. In the variety *Paul Krüger*, for instance, the attack on the tubers consists of an irregular yellowishbrown spot which is more densely colored in the centre and gradually becomes less so towards its edges, so that no definite line can be drawn between affected and normal portions. In the central area of the spot the skin is ruptured in various directions so that it presents the appearance of a net work, or there may be one longitudinal rupture crossed with numerous irregular cross ruptures: these are however seldom or never too deep and the spots do not increase in size as is the case with the variety *Schotsche Muis*. Yet under certain not yet fully understood conditions, very likely moist soil, this variety can show tuber affection that resembles fully the tuber affection of the variety *Schotsche Muis*.

It is very fortunate for the study of stipple-streak and perhaps also for leaf-roll, mosaic, crinkle, etc., that there is such a variety as the *Schotsche Muis*, which owing to its supersusceptibility shows the effects of the disease on the tubers as well, as this makes it possible to study the mode and rapidity of spreading of the pathogen through the plant.

*d. The tubers in storage.* So far we have seen what happens during the first year to the healthy potato plants when attacked by stipple-streak, and we have also seen the young pathologic changes on the tubers. Now we must follow up the question further and see what happens with the infected tubers during winter and the following season.

In those cases and varieties where the tubers do not show distinct or only slight symptoms of infection they may remain so during the whole winter until planting. While tubers from diseased plants from varieties which show the disease on the tubers as well, even though at the time of harvesting they may have been perfectly healthy, will show later on the disease and usually within the first or second month after harvesting. If we cut some of these tubers through the affected portion or affected eyes we will see that the affection is very superficial and limited only to the periderm and outer cortex and that usually the affected area is not more than one millimeter thick. The affected area is sharply defined and has a dark brown color. If we cut very thin sections through the affected area and look at them against the light we shall see that between the dark

layer and the rest of the tuber there is a more or less thick layer of translucent but not discolored cells. They have this appearance on account of being free from starch. If we cut the tuber through the affected stemend we shall see that here the browned and blackened layer is much thicker and may reach a depth of over one centimeter and extends further along the vascular bundles. Some of the heavily affected tubers when cut in cross or longitudinal sections show that their whole interior is affected, having a marble or net-like appearance, caused by the numerous more or less small groups of dead and brown-colored cells. These groups of dead cells grow bigger and bigger, joining the neighbouring dead cells and so sooner or later the whole tuber may become a brown spongy mass, shrivels and dries up completely representing a mummy. This marmoration is at first more severe in the vascular bundle tissues, but it is never uniform or continuous over the whole vascular ring as to form a black ring, as APPEL describes it. Not in all of the small number of cases where the tubers show internal browning and spotting do they result into death of the tubers, such tubers usually persist during winter and give rise to new plants when planted.

Internally affected tubers can be recognized by their uneven and somewhat granular or pock-like surface, resembling somewhat fresh *Phytophthora* infections, also by the deep-lying brown blotches which are visible through the periderm of the tuber, if only the latter has not been discolored or injured during the digging and subsequent handling.

It was mentioned above that the eyes are most commonly the portions of the tuber that show the symptoms of the disease and it is on the eyes that we see a most intensive and interesting development of these symptoms. The external tissue of the depressed eye in a diameter from one to several centimeters is killed, as described above, and the first scale leaves now dead are usually broken off and the whole eye, externally at least, is dead. Yet before long the growing point of the new shoots pushes through the dead layer, but before reaching any size it also becomes brown, dies, and dries up. New sprouts then come out, but they also die. In a large number of cases the dying off of the tissues in the region of the eye which usually is restricted to the outermost layers of cells, may advance considerably in the interior of the tuber, forming an irregularly conical or hemispherical hard black structure of dead cells, which upon boiling of the tubers can be taken out in contact. This agrees completely with the older descriptions of the disease. In some cases no sprouts whatever appear on the surface,

while in others the first or second sprout reaching the surface succeed in obtaining considerable size and if conditions are favorable will form a new plant. At this time and even before this the first sprout begins to get brown colored, the browning of the sprout advances from the base upwards and soon reaches the secondary sprouts as well. This browning may advance uniformly over the whole sprout or it may advance upwards in form of stripes. Once the sprouts have reached a size of one or more centimeters they seem to be more able to stand the disease and it is in this condition that the tubers are usually planted in spring.

### **B. Secondary form.**

If we plant the tubers of stipple-streak plants as described above, we shall see that some of them will never form any sprouts; they are some of the tubers that have been affected internally, also the tubers whose eyes have been destroyed completely and permanently. Other tubers will send out sprouts and numerous roots, as APPEL observed it, but fail to reach the surface of the soil. A third group of tubers, which is by far the greatest of all, will germinate quite regularly, sending out quite as many sprouts as healthy tubers do. During the first week or two after the appearance of the new sprouts above the ground we shall see, that they are apparently normal, i.e. they have a normal green color and are free from any spots or discolorations. Yet a careful examination of the new plants, be they very small or as high as 15 centimeters, will show that they are not at all normal. Their leaves have much shorter petioles, the leaflets are more or less undulated and crinkled and the two lobes stand at a much smaller angle to each other than the lobes of healthy leaflets as is shown in plate 1, fig. 1.

The color of the leaves, though normal dark green, is not of the same density over the whole leaf and represents a picture similar to that of very slight mosaic. Before long there appear on the leaves the second and more reliable symptoms of the disease, namely the browning of the veins and brown spots on the leaves, shortly after or at the same time and in some cases even before this there appear brown stripes on the stem. Let it be remembered that now we have before our eyes very young plants, which in this stage whether healthy or diseased have nothing typical about them and first from now on does the striking difference between healthy and stipple-streak diseased plants begin to become more and more apparent. While the healthy plant continues to develop rapidly spreading out, forming on all sides many leaves, having long internodes and

thick angular stems, the plants from infected tubers represent in every respect a directly opposite picture. They remain small, stunted, with short internodes, thin, round, and stripped with quite pronouncedly crosswise split stems. The leaves show distinct brown spots, the veins of the leaves are also browned and develop less rapidly than the surrounding portions of the leaf, this causes a downward bending of the leaflets and the whole leaf and the curling, crinkling and wrinkling of the leaves, the stems are covered with brown stripes, or are irregularly or uniformly brown. The whole plant has now a lighter green color, and is very brittle, we need only touch the leaves to make them drop off or partly break off and remain hanging on the stem. But even without this the leaves soon begin to fall off, proceeding from down up the stem, until very soon there remain only a few leaves at the top of the plant and the plant takes a palm-tree like form as ORTON expresses it. Soon the whole plant wilts, dries up and falls on the ground. This usually takes place during the first month after the appearance of the plant above the ground. Before long new shoots come out from the underground stems, which though sometimes split and slightly browned, remain normal. These new sprouts pass through exactly the same phases as the sprouts that preceded them, they may also die and new shoots come out, at which time the plants are being dug out. Not in all cases are there new sprouts formed after the death of the first, nor are new sprouts formed three times in all cases.

We see from the above that the disease as we saw it on the newly infected plants is something entirely different from the disease we saw on the plants produced from the tubers of the primary infected plants and it is not at all surprising that the two phases of the disease have been generally considered as two distinct and independent diseases.

If we dig out the secondary streak plants we shall see that in most cases the mother-tuber has not rotted, and that it is quite hard and watery, having a rough and corky surface, but this is the case also with all of the running-out diseases of the potato. Besides the mother-tuber we shall see that there are one or more small tubers; in some cases no new tubers are formed at all. These tubers are usually brown-colored on the outside, their periderm and outer cortex are usually split in various directions. The tubers lack the healthy skin of the normal tuber and are usually rough. When planted they may in some cases also give rise to a secondary streak plant, which never forms new tubers and usually dies early in the season.

### C. Stipple-streak compared with other potato diseases.

A comparison of stipple-streak with some of the other potato diseases is important from two stand-points. From a practical stand-point the comparison is important because it enables us to distinguish and separate stipple-streak from other potato diseases which do resemble it in one or another way. From a scientific stand-point it is important because stipple-streak, so far at least as its symptoms and development are concerned, stands between the etiologically known and etiologically little understood diseases of the potato plant. In its primary form it hardly differs from many of the bacterial diseases of plants: it is a spot and wilt disease, causing a rapid and certain wilting and death of the infected plants and it has been considered as a bacterial disease by APPEL, ORTON, BARRUS, GÜSSOW and others. In its secondary form it is a decidedly running-out disease like crinkle, mosaic and leaf-roll. From these three diseases it differs only in severity. What the last accomplish gradually and during number of generations it does only in two or three generations. It is the most severe disease in every respect of all of the running-out diseases of the potato. This severity and its much more pronounced symptoms cause it to resemble some of the fungus and bacterial diseases of the potato. It resembles the bacterial disease in the general habit and wilting of the infected plants. In some cases it may be mistaken for the *Verticillium* wilt, which does show on some varieties, before the appearance of the yellow discoloration and loss of turgidity of the leaves, irregularly scattered over the leaves dark brown spots; they are however much larger, sometimes over one cm. in size and never do spread along the veins.

Stipple-streak may be often mistaken for the early blight of the potato. The first *Alternaria solani* infections in Holland appear quite late in summer during the month of August, the spots are much smaller than usually and somewhat resemble, on some varieties, the stipple-streak spotting. The concentric rings in the early blight spots are in many instances quite absent or not very distinct, they are however seldom or never seen to run over the veins, as is usually the case with stipple-streak spots.

A still undescribed disease for which the name „Leafdrop-streak” has been suggested by Professor QUANJER, and which somewhat resembles the running-out disease of the potato and causes dropping off of the leaves and striping of the stems of the infected plants, may also be mistaken for stipple-streak.

They resemble each other in that both diseases cause a dropping off of the leaves and striping of the stems and in their general appearance and development. But they are two distinct and decidedly different diseases. Leafdrop-streak causes no spotting of the leaves whatever, it develops much slower, so that only some of the infected plants die before the death of the healthy plants of same variety. The irregularly running streaks which it produces on the stems of infected plants have an irregular outline and sharply defined borders, they are slightly sunken and the epidermis over them is usually also dead and brown colored, while the streaks on the stem caused by stipple-streak are usually straight, their borders are not well defined, they lay under the usually still healthy epidermis and are not sunken. The symptoms on the tubers of leaf-drop-streak are less severe than those of stipple-streak, they consist of large light brown blotches, with undefined border lines somewhat resembling the symptoms of stipple-streak as described for the variety Paul Krüger.

Much greater however is the similarity of stipple-streak to crinkle. Numerous cases have been seen where it could not be decided definitely whether the plants in question were infected with stipple-streak or crinkle. In most cases, however, the two diseases are distinctly different, but the symptoms of primary stipple-streak on one and the same variety may sometimes be a little finer, and those of crinkle somewhat coarser than usually, which gives us symptoms that stand exactly between the symptoms of the two diseases; these are the difficult cases for diagnosing. The following is a comparison of stipple-streak with crinkle.

PRIMARY FORM.

STIPPLE-STREAK.

1. Infected plants as a rule die sooner or later after the infection and long before the natural death of the variety.
2. All leaves, except in some cases the lowest, get brown spotted before wilting and dying.
3. Spots always angular, usually larger, well defined, and always through the whole leaf and of same size and form on both sides.

CRINKLE.

1. Infected plants as a rule persist until shortly before the natural death of the variety.
2. Not all and more commonly the older leaves do get brown spotted.
3. Spots usually very fine, almost microscopic, sitting deeper in the mesophyll of the leaf, usually not coming through the epidermis.

## STIPPLE-STREAK.

4. Young leaves practically normal and showing only a slight mosaic like variation in color.
5. Stems striped with long and heavy stripes.
6. On some varieties the tubers of the infected plants show distinctly effects of the disease.

## CRINKLE.

4. Young leaves usually pronouncedly crinkled and showing a heavy mosaic like variation in color.
5. Stems as a rule free from stripes. Stripes when present are very fine and usually on the ribs.
6. The tubers of infected plants never show distinct effects of the disease.

## SECONDARY FORM.

- |  |   |
|--|---|
| <ol style="list-style-type: none"> <li>1. The second year sick plants very small, degenerated, and brittle as glass.</li> <li>2. Leaves spotted, veins on lower side of leaves here and there dark brown, browning extends in the mesophyll.</li> <li>3. Lower leaves begin to drop off early in the growing period.</li> <li>4. Stems striped or wholly brown with cross splittings.</li> <li>5. Plants usually die before the healthy neighbouring plants have reached full size.</li> <li>6. Few very small tubers.</li> <li>7. Tubers discolored, brown, split and rough.</li> </ol> | <ol style="list-style-type: none"> <li>1. Second year sick plants usually quite large and less degenerated, not or only slightly brittle.</li> <li>2. Leaves free from spots, veins on lower side of leaves here and there light brown, browning never goes beyond the veins.</li> <li>3. Lower leaves begin to drop off later in the growing season.</li> <li>4. Stems not always striped, not discolored. Stripes, when present, very fine.</li> <li>5. Plants usually die after the neighbouring plants have reached their full size.</li> <li>6. More and larger tubers.</li> <li>7. Tubers not discolored and smooth.</li> </ol> |
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## NATURE OF THE DISEASE.

The stipple-streak disease of the potato plant like leaf-roll, mosaic and crinkle is a systemic disease. Even in its primary form it usually spreads into all shoots born on one and the same tuber. If all shoots of a hill have been infected and have died subsequently from the disease before the digging of the tubers, all of the latter will be also infected and when they are infected they are as a rule wholly infected, i.e. all plants coming up from such a tuber will show secondary symptoms of the disease, though in some cases some of the shoots do so more, others



less pronouncedly. Cases have been seen also where the tubers formed on a still healthy sister stem of a diseased one are already heavily infected and show typical symptoms of stipple-streak infection. This fact lead the writer at first to think that the infection of the tubers may take place also from outside, through the soil, which as will be seen later is not so. It seems therefore possible that sometimes the pathogen invading down the infected plant passes through the mother-tuber into the base of the still healthy sister shoots and from there through the stolons into their tubers before reaching their aerial portions. There have been seen also cases where the organic connection between the various sister plants of a hill has been destroyed through the rotting of the mother-tuber, or where the plants have been dug out at a moment when only some of the shoots did show the symptoms of the disease: in such cases the tubers of the still healthy plants are also healthy and did remain so. There is so far no experimental evidence to show that some of the tubers of an already heavily infected shoot can remain healthy and give healthy plants, nor is there any observation to support this.

Tubers of the variety Schotsche Muis showing few stipple-streak blotches or blisters and having still some perfectly normal eyes when disinfected on the outside in 2<sup>o</sup>/<sub>100</sub> mercuric chlorid solution for 30 minutes and cut carefully each time with a sterile knife into several pieces so as to separate the eyes showing the effects of the disease from those that are still apparently healthy, when planted did give in all cases secondary stipple-streak plants, regardless whether the portions did or did not show the symptoms of the disease.

All tubers of the variety Schotsche Muis from stipple-streak plants over one thousand in number and showing stipple-streak blotches on their surface as are shown in plate 5, fig. 2 and 3, when planted gave without any exception only secondary stipple-streak plants. No such symptoms have been seen on any of the numerous other tubers of same variety that have been examined and planted. This proves beyond any doubt that the eye disease or blindness of the potato tubers, which has been considered previously as a distinct and different disease, is nothing else than stipple-streak infection on what may be called highly susceptible varieties, as is the variety Schotsche Muis.

#### **Transmission of the disease.**

*a. The soil.* Whatever the pathogen of this disease may prove to be, it is certain that it does not leave the infected

plant under ordinary conditions and that it very likely dies with the death of the host plant. Healthy tubers of the variety Schotsche Muis that have been stored during the whole winter in a not too dry cellar in sacks between 95 % of positively and heavily stipple-streak infected tubers of same variety, after planting gave absolutely healthy plants, which remained healthy during the whole season.

In each of fourteen pots were planted one healthy tuber of the variety Schotsche Muis and one from a primary stipple-streak plant of same variety. In seven of these pots the infected tubers were left whole; in the other seven they were cut longitudinally in two pieces and placed on both sides of the healthy tuber, which was placed in the centre of the pot. In all of the fourteen pots the healthy as well as the diseased tubers sent out numerous shoots. The healthy tubers gave healthy plants which remained healthy until ripening. The diseased tubers gave diseased plants. The upper diameter of the pots used in this experiment was 20 cm. so that the healthy and diseased plants were very close and were touching each other, while their root systems were thoroughly interwoven. Stolons and tubers of healthy and diseased plants did as a rule touch each other and were often firmly pressed against one another in the small pots, yet upon digging all of the numerous and large tubers of the healthy plants were as healthy and as free from any spotting or discoloration and as smooth as any tubers can be, whereas the few and very small tubers of the infected plants showed heavily the symptoms of the disease. They were practically covered with the typical blisters and brownish blotches as described above and many of them were split, and had a very rough surface, as is typical for the secondary stipple-streak tubers of this variety. This experiment shows conclusively that the pathogen cannot pass from plant to plant through the soil, the water or the air even when the plants are in one and the same pot. Same experiment was made last year in the Experiment Garden at Andijk where on a small potato field which had 75 % of stipple-streak plants there were planted on June 5th same summer again healthy Schotsche Muis tubers, but all plants remained healthy. This season there were planted the halves of 10 healthy Schotsche Muis tubers under stipple-streak plants. The other halves were planted as checks. Both the checks and the tubers planted under the stipple-streak plants gave stipple-streak free plants which remained so until digging.

*b. Plant juice.* SCHULZ and FOLSOM claim to have been able

to infect potato plants with stipple-streak by means of juice from an infected plant. „In 1921, they write, juice from a streak plant, applied to 20 mutilated Green Mountain and Irish Cobbler plants caused infection in 19, with typical symptoms appearing in some in 12 days”. In order to verify this statement 20 young and vigorous potato plants in one row of the variety Schotsche Muis, which is our most susceptible variety to stipple-streak, also 10 old plants of same variety some of which were beginning to die, were infected on July 11th with juice, three plants of each hill being infected. The infection was done in the following way: The juice of infected stems or petioles was pressed out with a pair of forceps on a flattened inoculation needle; this needle which carried each time a large drop of juice was then pressed into the uppermost portion of the stems, just below the growing point. Thanks to the surface tension of the split stem the juice from the needle was in all cases drawn into the narrow but deep wound of the stem. About a month later (August 7th) these plants, which now had reached their full development, were carefully examined and were found to be perfectly healthy. They were then infected once more in same way, three plants of each of the 20 hills or together 60 plants were again infected. On August 28th or 20 days after the second infection they were again carefully examined and found to be perfectly free from stipple-streak. Some of these plants were beginning, at this time to get yellow due to natural ripening as did some of the numerous check plants around them. The above results make it highly improbable that the plants infected by SCHULZ and FOLSOM have become diseased as result of their infection. This view is supported also by the fact that all efforts of Professor QUANJER to transmit some of the related diseases of the potato by means of juice from infected plants so far have not given a conclusive result. It seems very likely that even if this should be possible under certain conditions it is by no means an easy and certain method of transmission of these diseases. In this respect these potato diseases are decidedly different from the mosaic disease of tobacco and cucumber.

*Grafting.* So far it has been possible to transmit stipple-streak from a diseased to a healthy plant only by creating an organic connection between them. This has been accomplished in two ways. The one is by joining sections of healthy tubers with sections of infected ones; the second is by grafting infected plants on healthy ones.

**TUBERS.**

When the freshly cut surfaces of a healthy and a diseased tuber of a primary stipple-streak plant are joined and bound tightly so as to grow together, then planted, they will produce a healthy and a diseased plant respectively, but before the healthy plant reaches any size it will suddenly show the symptoms of primary stipple-streak infection. The disease proceeds further in same way as described above. When however between the two freshly cut surfaces of the two tubers is placed a piece of hard paper as large as the tubers are, which prevents the two tubers from growing together and from forming a living connection between the two tubers, then the plant coming from the healthy tuber remains healthy.

**VINES.**

It is possible to transmit stipple-streak from a diseased plant to a healthy one by grafting the diseased plant or portion of it on a healthy plant. Not every variety seems to be suited, however, for such experiments, as in most cases the infected graft usually wilts and dies shortly after the grafting and before the growing together of the two cut surfaces has taken place. A large number of graftings with the varieties Schotsche Muis, Paul Krüger and Douwe Jan gave no results. It is interesting to note here the observation that infected plants or portions of them when partially dipped in fresh water will remain alive much longer than when grafted on one of the above varieties and kept constantly moist in a moist chamber. Portions of the variety MacCormick with primary stipple-streak infection when grafted on Paul Krüger and Schotsche Muis plants remain fresh and alive for a long time, thus making possible the growing together of the two cut surfaces and the passage of the pathogen into the healthy plant. Here, as in the cases of the graftings with all of the other potato diseases of this group, the portion of the grafted healthy plant to show first signs of infection is the young shoot coming from the grafted stem just below the place of grafting. The incubation period here runs upwards from 14 days depending on the case and the condition of the grafted plant. The infection then spreads gradually to the neighbouring shoots of same stem and then passes over to the other stems of same plant. Not seldom the newly infected young shoots die almost immediately after the appearance of the first signs of the disease on them. This rapid dying off of the primary infected young and succulent stems and shoots and the much slower death of the secondary sick plants suggests

that there must take place in the course of time an adjustment or adaptation between the host and parasite. What in the primary form of infection was absolutely deadly, in the secondary form is much less so, at least much slower and in the light of an experiment, to be discussed below, it does not seem improbable that the life of a secondary stipple-streak plant may be prolonged under certain conditions almost indefinitely and the length of the disease instead of covering three generations may be made indefinite, and the relative symbiosis existing between host and pathogen may be changed into an absolute symbiosis.

The stipple-streak disease of the potato which in some years appears in epidemic form, however, must have some mode of natural dissemination, which though not yet understood exists nevertheless. Often we see perfectly healthy and fully developed plants standing far away from stipple-streak plants or in fields free from any disease, which suddenly become infected with primary stipple-streak and die within short time and long before the natural death of the surrounding healthy plants. One would naturally expect that such primary infections should in most cases appear among the plants standing around or near a secondary or primary stipple-streak plant, as is even claimed by SCHULZ and FOLSOM, this is however not the case, at least it does not happen often enough to justify this supposition. A very large number of secondary and primary stipple-streak plants with the surrounding healthy plants located under various and most different soil and other conditions have been watched often for over three months, but nowhere except in one case did there appear any stipple-streak on the surrounding or nearby plants. Out of forty two healthy hills of susceptible early varieties from fields that had over 50 % of stipple-streak plants, harvested early in July, when planted the following year only four or 9.5 % of them yielded some secondary stipple-streak plants, no primary infections appeared in this experiment. The whole experiment comprised 770 plants, of which 23 plants or 2.6 % developed secondary stipple-streak. In one case however out of 50 healthy plants of the variety Schotsche nuis standing in two rows, between which there was a row of secondary stipple-streak plants, two of them standing in one and the same row became infected and showed typical symptoms of primary stipple-streak infection, while in the other six rows, standing next to the row with primary streak plants, there appeared no infection whatever. The scattered and incidental infections of stipple-streak, which is the rule and not the

exception in the case of this disease, may be more due to the fact that the source of infection; i.e. the infected plants die too rapidly and usually too early in order to form a permanent source of infection for the whole growing period, as is the case with leaf-roll, mosaic, crinkle, etc. than due to the possibly different mode of dissemination. If it should be established later on that here too aphids or other insects are spreading the disease, then it will be easy to comprehend why stipple-streak infections in most seasons are rare and scattered, and this is because the infected plants die and with this the source of infection disappears long before the appearance of the aphids. Here we seem to have to do with a disease whose severity and destructiveness defeats its own end, they make impossible its further spreading and lead to a natural elimination of the disease. This fact gives us an effective control measure against this disease, which will be discussed in another chapter.

#### **Influence of temperature on the development of the disease.**

The temperature has a very marked influence upon the appearance and the further development of stipple-streak. Fifteen tubers from primary stipple-streak plants of the variety Schotsche Muis showing plainly the symptoms of the disease were planted on February 20th in pots and left in the hot house at a temperature varying from 15 to 20° C. After some time they came up and a week later showed decidedly all symptoms of secondary stipple-streak. Ten days later, April 8th, all of these plants were taken out and placed outside in the ground under a glassframe. The temperature outside varied from 5 and less than 5 to 15° C, being during the largest portion of the time between 5 and 10° C. The plants continued to develop gradually reaching a size of 20—25 cm., while the symptoms of the disease began to disappear gradually. Two weeks later most of the plants were, when examined superficially, apparently healthy; their leaves were dark green, smooth and spread out. Upon careful examination, however, the symptoms of stipple-streak were easily to be seen on most of the plants. The bases of the stems had numerous typical stipple-streak stripes and spots. They were the stripes that were on the stems before the plants were taken out. The portions of the stems formed after they were taken out were perfectly free from any stripes or other symptoms of the disease. The primary leaves which in the hot house did show typical symptoms of secondary stipple-streak had meanwhile shriveled and fallen off, whereas the new leaves were in every respect perfectly normal, except that on

their lower sides they showed here and there small black streaks over the veins. These symptoms were in all respects most typical of the primary form of stipple-streak as seen in nature on newly infected plants.

It was evident from the above that the low temperature outside must have been the cause of the retarding of the disease. In order to establish whether this was really so, three of the plants were placed again in the hot house. One of them did show at this time the symptoms of primary stipple-streak, the second showed very little of the disease, while the third had nothing more of the disease than few small black streaks on the stem just above the ground. Only 48 hours later there was to be seen in all of the three plants a marked advancement of the disease. Five days later some of the leaves of the first plant were so badly spotted with typical stipple-streak spots that they wilted completely. During the same period of time the disease increased materially on the second plant, while on the third plant which before was apparently normal there appeared numerous typical streaks and spots on the leaves, making the plant decidedly primary stipple-streak. The rest of the plants that had been left to stand outside with the coming of warmer weather later showed also the primary symptoms of the disease and soon succumbed to it completely.

It is evident from the above that the low temperature was the cause of the retarding of the disease. The temperature of  $+5-10^{\circ}\text{C}$  during most of the time and of  $15^{\circ}\text{C}$  during the noon hours, while still high enough for the gradual and normal development of the potato plants was evidently too low for the growth and propagation of the pathogen. That the weather conditions, respectively the temperature and very likely the moisture are important factors in the development of stipple-streak is shown also by the different rapidity of development of this disease during the last two years. The summer of 1921 was fairly warm and very dry and in most cases the secondary stipple-streak plants were already dead in the later part of May and the first part of June. In this connection it should not be forgotten that in 1921 the weather has been dry and warm ever since the beginning of February and that the potatoes were planted and came up very early in spring. The primary stipple-streak infections during the same year did develop in most cases very rapidly and within 2 or 3 weeks the infected plants usually did die. The year 1922 was on the contrary cold and rainy, especially during the summer. The secondary cases of stipple-streak did not differ much in their development from

those of 1921, because the spring was quite warm and dry. The primary infections, however, which were to be seen first during the summer did develop much slower and in some cases, a whole month or more had to pass before the disease could appear on the neighbouring sister shoots.

#### METHODS OF CHECKING NATURAL TRANSMISSION.

At the beginning of the work on stipple-streak, when the systemic nature of the disease was not certain, were made several experiments for treating the tubers from infected plants in order to free them from the infection, all of which did, however, give absolutely negative results. Positively infected tubers of primary stipple-streak plants disinfected in 2 % copper sulphate for one and two hours and in 2  $\frac{0}{100}$  mercuric chlorid for half and one hour when planted gave in all cases secondary stipple-streak plants. Similar tubers heated with dry air at a temperature of 44—46° C for 5, 15 and 24 hours upon planting gave also in all cases secondary stipple-streak plants.

In view of the nature of the disease it will be impossible to destroy the pathogen of stipple-streak in the tubers without injuring the tubers themselves. From the numerous observations made on this disease it seems highly probable that stipple-streak can be successfully controlled by elimination of the tubers and the young plants that show the symptoms of the disease. The elimination of the infected tubers is not always possible as most of the varieties do not show the disease on the tubers. For the variety Schotsche Muis, however, where stipple-streak is of great economic importance the infected tubers usually do show the symptoms of the disease and can be easily eliminated. This had been already done in North Holland this spring and gave very good results. Lots of seed tubers from which the tubers showing stipple-streak symptoms had been eliminated gave practically no sick plants, while the picked-out infected tubers from North Holland planted in Wageningen gave in all cases stipple-streak infected plants.

It is natural to suppose, as long as the true nature of this disease has not been learned, that the infected plants are the main if not the only source of infection and that an elimination of the latter as soon as they can be recognized will be an effective control measure against stipple-streak. In the case of leaf-roll, mosaic and crinkle which cause, as is known, only a gradual decline of the yield it has been found feasible and from economical stand-point desirable to advise only selection



of seed-tubers from healthy plants as control measure against these diseases. In the case of stipple-streak, however, which already in the second generation decreases the yield practically to zero, elimination of all infected plants as soon as they can be recognized will be the most efficient control measure. The accomplishing of this will be an easy matter for every potato grower whose attention has been called to this fact. The diseased plants from their very appearance above the ground to their wilting and death are easily recognizable as is shown in plate 1, fig. 1—4 can be easily taken out, gathered and destroyed or used as animal food.

That the prompt and careful elimination of the infected tubers and plants will be an effective control measure against stipple-streak seems plausible not only in view of the writers observations on this disease, but there are also numerous statements in literature that this disease has been controlled successfully in this way in England and on the continent of Europe as early as 1788.

## DE STIPPEL-STREEPZIEKTE VAN DE AARDAPPEL.

De ziekte, die in 1921 in een min of meer epidemische vorm in de vroege aardappels, vooral in de „Schotsche Muis”, in Noord-Holland optrad en waaraan Prof. QUANJER de naam „stippel-streep ziekte” heeft gegeven, gelijkt zeer veel op de degeneratieziekten van de aardappel: bladrol, mozaiek en krinkel.

Deze ziekte is een van de oudst bekende ziekten van de aardappel en is onder den naam Krul of Kroesziekte vanaf de tweede helft der achttiende eeuw bekend geweest. De laatste namen zijn klaarblijkelijk ook gebruikt om de ziekte aan te duiden, die nu „krinkel” wordt genoemd en misschien ook wel voor mozaiek.

Stippel-streepziekte is identiek met de oogenziekte van de aardappel. De stippel-streepziekte van de aardappel is zeer algemeen verspreid in West-Europa en Noord-Amerika. Zij is tot dusver waargenomen bij een groot aantal vroege en late aardappel-varieteiten.

De meest karakteristieke symptomen van deze ziekte zijn, zooals de naam reeds aangeeft, de stippels op de bladeren en de strepen op de stengels van de aangetaste planten. Het eerste optreden der ziekte in haar primaire vorm verraadt zich door talrijke hoekige donker-bruin tot zwarte vlekken op de bladeren van de plant. De vlekken gaan door het geheele blad heen en hebben aan beide zijden van het blad dezelfde grootte en vorm. De vlekken zitten gewoonlijk op de bladnerven, hetgeen in het bijzonder geldt voor de vlekken op de jongere bladeren, terwijl zij op de oudere bladeren meer tusschen de nerven zitten. Wanneer de vlekken de nerven in hun loop volgen gelijken zij meer op een kort streep dan op een vlek. Keert men zulke bladeren om, dan zal men de meeste nerven bruin gekleurd zien.

Bijna gelijktijdig met het verschijnen van de vlekken op de bladeren ontstaan er donkerbruine strepen op de stengels en de bladstelen van de aangetaste planten. De bladeren, die de meeste vlekken hebben, beginnen spoedig te verwelken, ze breken gedeeltelijk af en blijven aan den stengel hangen. De bladeren, die het eerst gaan verwelken en sterven zijn die, welke op het middengedeelte van de plant staan. De bladeren er boven, die vervolgens vlekken krijgen, verwelken ook en vallen korten tijd later af, waarna de geheele top van de plant verwelkt en in elkaar schrompelt. De ziekte zet zich dan naar beneden voort en doet, wanneer het weer warm is, de geheele plant na korten tijd afsterven. De strepen op de stengels nemen ook langzamerhand in lengte en breedte toe, zoodat de geheele stengel bruin gekleurd kan zijn. De ziekte verschijnt eerst op een enkele scheut en verspreidt zich daarna langzamerhand over de geheele plant.

De knollen van sommige varieteiten, b.v. die van de varieteit Schotsche Muis vertoonen ook symptomen van de ziekte. Deze bestaan uit bruine blaren en vlekken op of nabij de oogen en het stengeleinde van de knollen. De blaren, die eerst een weinig uitpuilend zijn, drogen na het oogsten op en wat overblijft is een donkerbruine of kaneelkleurige vlek. Wanneer de blaren op jonge en snel groeiende knollen verschijnen, splijt de kurklaag en de schors van de knollen in verschillende richtingen, zooals Pl. 5, fig. 1 aangeeft. Na het oogsten blijven de blaren en de verkleuring nog eenigen tijd voortgaan zich te ontwikkelen. Knollen van geïnfecteerde planten, die ten tijde van het oogsten een volkomen gezond uiterlijk hadden, kunnen na het oogsten blaren krijgen en verkleuren.

In het bijzonder geldt voor de grootere knollen, dat de beschreven symptomen op de oogen en vooral nabij het stengeleind voorkomen. Het buitenste gedeelte van de oogen wordt evenals de omgeving daarvan donker bruin en droogt op, zoodat de oogen dood schijnen, hetgeen zij soms inderdaad zijn. Vandaar de naam „oogenziekte”, die door aardappelkweekers wordt gebruikt om dezen toestand aan te geven. Knollen met zulke oogen, ofschoon inwendig geheel normaal, spruiten heelemaal niet en blijven tot laat in den zomer onverteerd in den grond liggen.

Wanneer knollen van primair geïnfecteerde planten uitgeplant worden, komen er planten uit voort, die de ziektesymptomen vertoonen, zoodra zij boven den grond verschijnen, maar deze secundaire vorm der aantasting verschilt aanmerkelijk van de primaire. Zij belemmert den groei zoodanig dat men dien dwergachtig kan noemen. De blaadjes blijven klein en kronkelen zich, de bladstelen zijn kort, zoodat de bladeren dicht aan den stengel staan, de er op voorkomende bruine vlekjes zijn minder talrijk dan op de bladeren der primair geïnfecteerde planten; echter zijn vrijwel alle nerven donker-bruin gekleurd. De stengels zijn met bruine strepen bedekt of zijn geheel bruin met ondiepe dwarse spleten. De onderste bladeren verwelken spoedig en vallen af of blijven aan den stengel hangen. Alle bladeren, evenals de geheele plant, zijn buitengewoon bros en wij behoeven bladeren of stengel slechts aan te pakken of zij breken af. Het sterven en afvallen van de bladeren schrijft hier naar boven voort, zoodat de geheele plant eenigszins op een palm gaat gelijken. Zulke planten sterven vroeg in den zomer, voordat de gezonde planten haar volle ontwikkeling hebben bereikt. Zij vormen slechts weinige en zeer kleine knollen, die verkleurd zijn, bedekt met blaren en talrijke spleten en een ruwe oppervlakte hebben. Zelden spruiten zij nog en als dit gebeurt, ontstaan er weer secundair zieke planten uit.

De stippel-streepziekte van den aardappel is een ziekte, die zich inwendig door de plant verspreidt zoodat men op een gegeven oogenblik alle spruiten gelijkmatig vindt aangetast. De knollen van zulke planten zijn gewoonlijk ook aangetast; de infectie van deze knollen is ook algemeen, d. w. z. dat alle spruiten van zulke knollen secundair zieke planten geven. Knollen, die de symptomen van „oogenziekte” vertoonen, leveren zoo er nog kiembare spruiten overgebleven zijn, secundair stippel-streepzieke planten.

De oorzaak van stippel-streep blijft, voorzover dit uit de genomen proeven is te beoordeelen, niet in den grond achter en gaat niet door den grond van plant tot plant.

Tot dusver is het alleen mogelijk geweest de ziekte over te brengen door de versch gesneden oppervlakten van zieke en gezonde stengels of knollen met elkaar te laten vergroeien, dus door enting van een zieke plant of gedeelte ervan op een gezonde, of wel door transplantatie van een zieke knol op een gezonde. In deze opzichten gedraagt zich stippel-streep geheel als bladrol, mozaiek en kringel.

De temperatuur heeft een duidelijken invloed op het optreden en de ontwikkeling van de ziekte. Wanneer knollen, van aangetaste planten afkomstig, uitloopen bij een temperatuur tusschen 5 en 10° C, groeien de planten door de ziekte heen, maar zij bezwijken eraan, zoodra de temperatuur boven 10° C stijgt.

Behandeling van de aangetaste knollen met chemische middelen of heete lucht bij een temperatuur van 44—46° C gedurende 24 uur bevrijdt ze niet van de infectie.

Verwijdering van aangetaste knollen en aangetaste planten, zoodra men ze kan herkennen, is het aangewezen bestrijdingsmiddel tegen stippel-streep. In 1922 had een nauwgezette verwijdering van de oogenzieke knollen bij de variëteit Schotsche Muis een bijna volkomen onderdrukking tengevolge van de stippel-streepziekte in de velden die in Noord-Holland met deze soort beplant waren.

Met het oog op de bestrijding is het een gunstige omstandigheid, dat het juist de vroege aardappelen zijn, die in zoo sterke mate van de stippelstreepziekte te lijden hebben. Want voor de teelt van deze soorten is het nazien der spruiten een onmisbare maatregel, die zonder groote extra kosten ons in staat stelt, de aangetaste knollen te verwijderen. Bovendien moeten aangetaste planten bij de grondbewerking worden uitgegraven.

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## DESCRIPTION OF PLATES.

### PLATE 1.

- Fig. 1. Leaf of the potato variety Paul Krüger showing symptoms of primary stipple-streak infection. Here the spots and streaks are large and represent the kind of spots and streaks commonly seen on the infected plants of these variety.

Blad van de aardappel varieteit Paul Krüger, dat de symptomen van primaire stippelstreepaantasting vertoont. Hier zijn de vlekken en strepen vrij groot, hetgeen voor deze varieteit typisch is.

- Fig. 2. Fully grown leaf of the potato variety Schotsche Muis showing symptoms of primary crinkle infection. Note the minute and numerous stipples.

Volwassen blad van de aardappel varieteit Schotsche Muis dat de symptomen van primaire krinkel-aantasting vertoont. Men lette op de kleine en talrijke stippels.

### PLATE 2.

- Fig. 1. Leaf of a primary stipple-streak infected plant of the variety Paul Krüger. Spots and streaks are much finer than in plate 1.

Blad van een primair aangetaste plant van de varieteit Paul Krüger, vlekken en strepen fijner dan in fig. 1.

- Fig. 2. Leaf of same plant as the leaf in fig. 1, but with much finer stipples and streaks, which resemble much those of the crinkle disease of potato.

Blad van dezelfde plant als in fig. 1. maar met nog fijnere stippels en strepen, zoodat deze eenigszins gaan gelijken op die van de krinkel-ziekte der aardappels.

### PLATE 3.

- Fig. 1. Leaflets of the variety Schotsche Muis (Victory) showing the signs of primary stipple-streak infection. The first leaflet to the left is older. Here the spots though distinctly angular are more or less rounded. The three leaflets on the right are younger. Here the spots are elongated, forming short streaks, the younger the leaves are, the more intensive is the spotting.

Blaadjes van de varieteit Schotsche Muis (Victory), die de symptomen van primaire stippestreep-aantasting vertoonen. Het eerste blaadje links is reeds ouder; hier zijn de vlekken, ofschoon nog duidelijk hoekig, min of meer afgerond. De drie blaadjes rechts zijn nog jong. Hier gaan de vlekken veelal in streepjes over; hoe jonger de bladeren zijn, des te intenser zijn zij gevlekt.

- Fig. 2. Leaflets of a primary stipple-streak infected plant of the old American variety Cowhorn. Note the absence of spots and the long streaks on the veins.

(Some think that old wild growing American varieties are resistant, that does not seem however to be the case).

Blaadjes van primair aangetaste planten van de oude Amerikaanse varieteit Cowhorn. Men lette op de afwezigheid van vlekken en op de lange strepen op de nerven.

(Sommigen meenen dat oude en wildgroeiende Amerikaanse varieteiten resistent zouden zijn; dit is echter niet het geval).

- Fig. 3. Leaflets of an primary stipple-streak infected plant of the variety Schotsche Muis.

Blaadjes van een primair aangetaste plant van de varieteit Schotsche Muis.

#### PLATE 4.

- Fig. 1. A secondary stipple-streak infected plant of the variety Schotsche Muis (Victory) just coming up above the ground. Photographed from above. Note the small, curled, backwards bent and with deep venation leaves.

Een secundair stippestreepzieke plant van de varieteit Schotsche Muis (Victory), die juist boven den grond komt, van boven gefotografeerd. Let op de kleine, gekrulde, achterwaarts gebogen bladeren en de diepe ligging der nerven.

- Fig. 2. For comparison an healthy plant of same variety and age. Ter vergelijking een gezonde plant van dezelfde varieteit en leeftijd.

- Fig. 3. A healthy plant of the variety Douwe Jan standing between two secondary sick plants. Note the hanging dead leaves and the palmlike form of the infected plants.

Een gezonde plant van de varieteit Douwe Jan, die tusschen twee secundair zieke planten in staat. Let op de hangende doode bladeren en de palmachtige habitus van de aangetaste planten.

- Fig. 4. A secondary stipple-streak sick plant of the variety Schotsche Muis.

Een secundair stippestreepzieke plant van de varieteit Schotsche Muis.

PLATE 5.

Fig. 1. Tubers of the potato variety Schotsche Muis, showing the characteristic splitting of the tubers of secondary and early primary infected stipple-streak plants.

Knollen van de aardappel variëteit Schotsche Muis, die de karakteristieke splijting vertoonen van de knollen van secundair en vroeg primair aangetaste stippelstreeplanten.

Fig. 2. Schotsche Muis potato tubers of primary infected plants, harvested in June and photographed immediately afterwards. Note the blister like swellings which split and dry up later, forming large irregular blotches.

Schotsche Muis knollen van primair aangetaste planten, in Juni geoogst en onmiddellijk daarna gefotografeerd. Let op de blaar-achtige opzwellingen die later splijten en opdrogen onder het vormen van groote onregelmatige vlekken.

Fig. 3. Schotsche Muis tubers of primary infected plants. Photographed two months after digging. All blisters have shrunk forming large and irregular dark brown or cinnamon brown blotches.

Schotsche Muis knollen van primair aangetaste planten. Twee maanden na het opgraven gefotografeerd. Alle bladeren zijn verschrompeld en in onregelmatige donkerbruine of kaneelkleurige vlekken overgegaan.



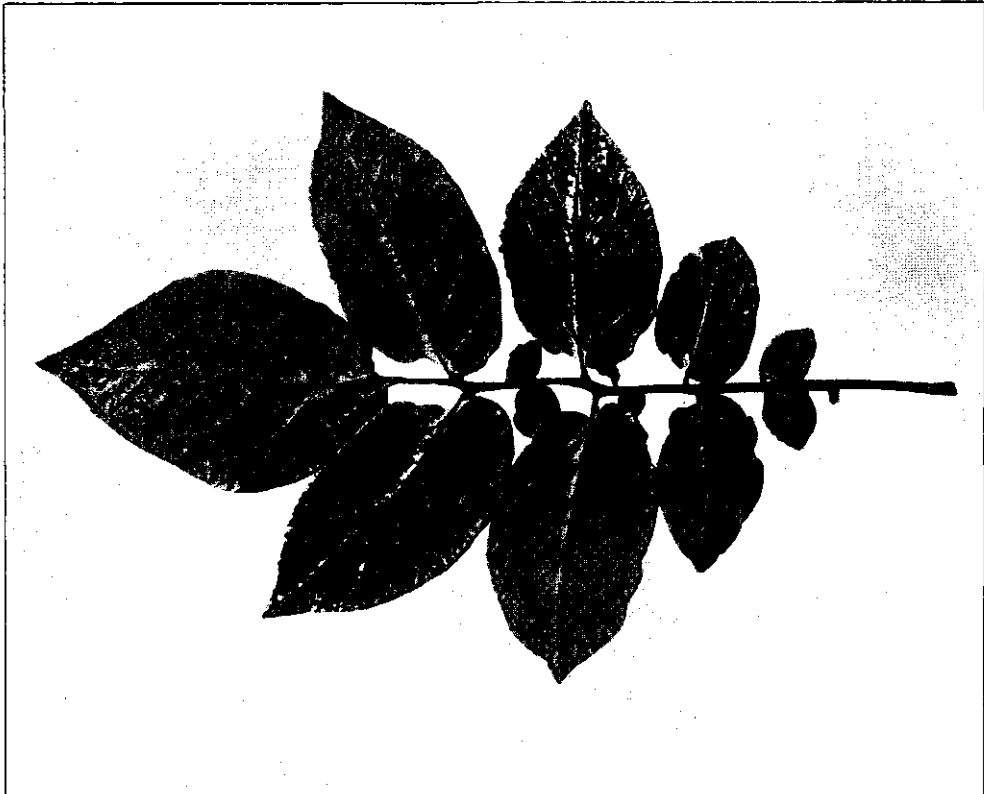


Fig. 2

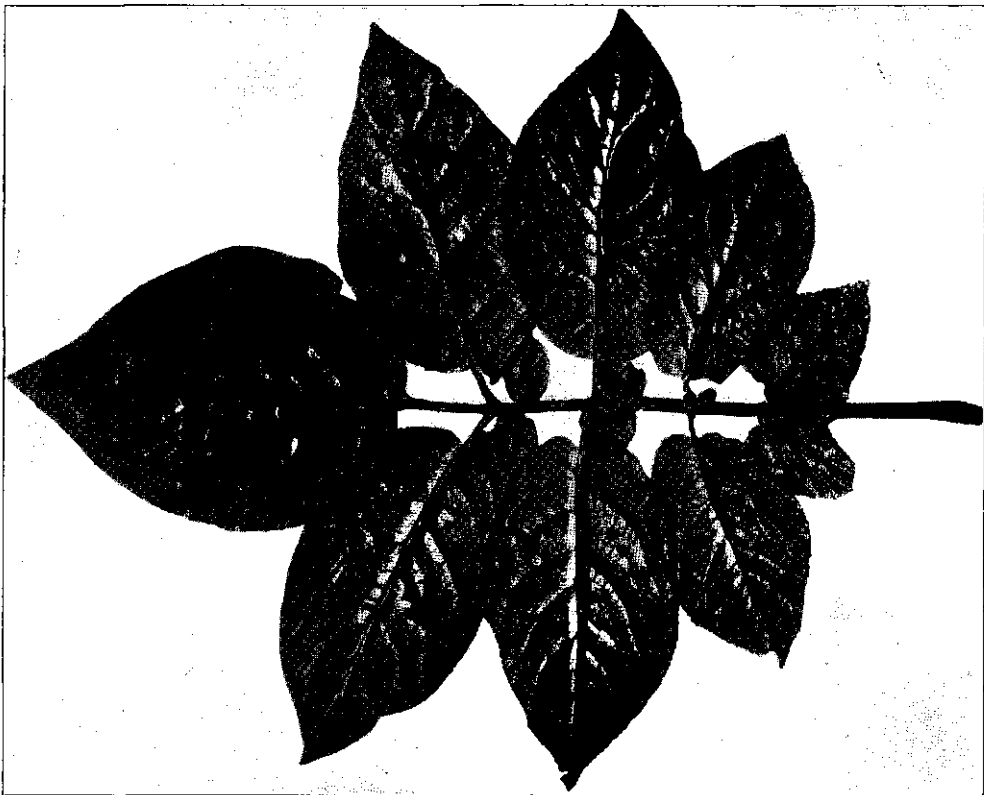


Fig. 1

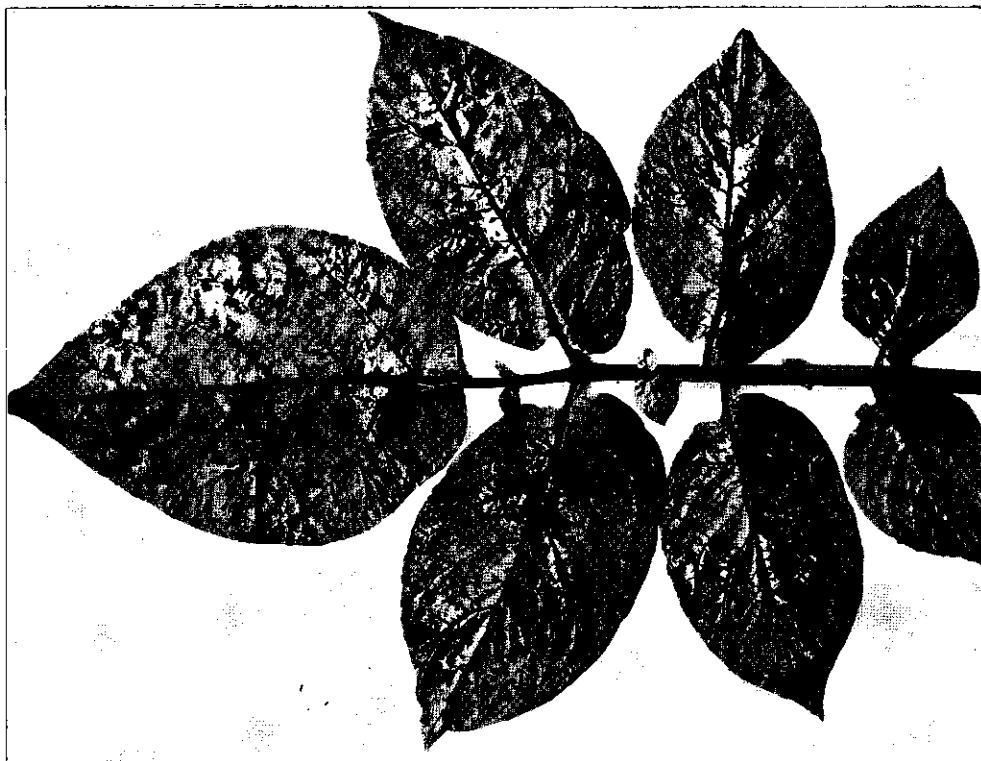


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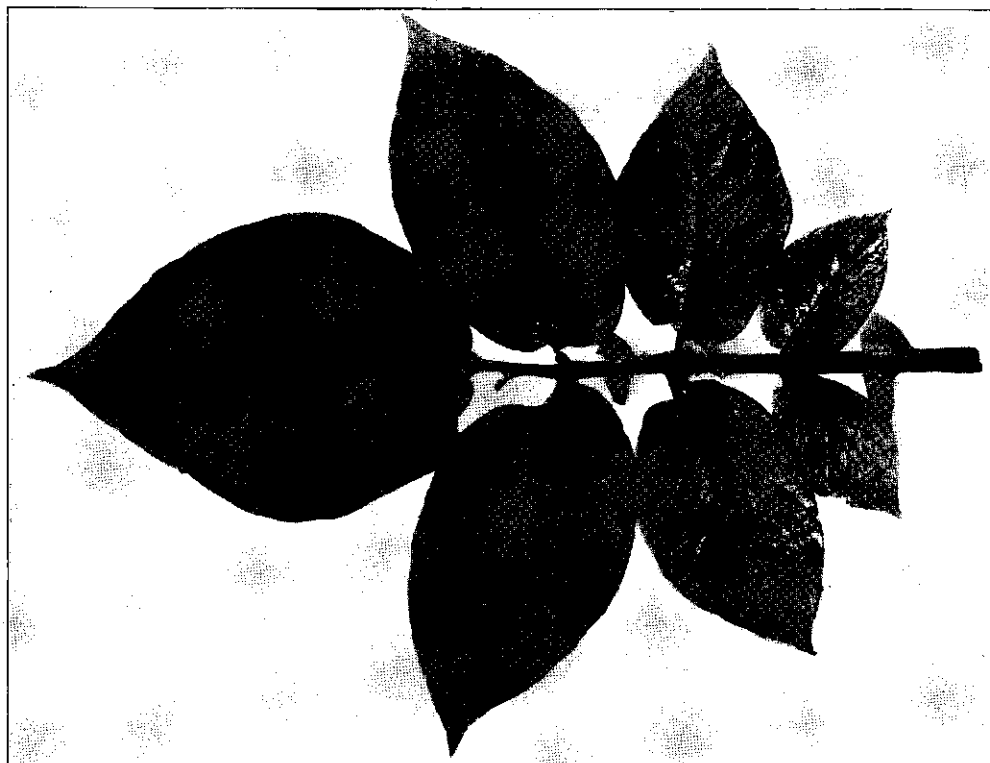


Fig. 1

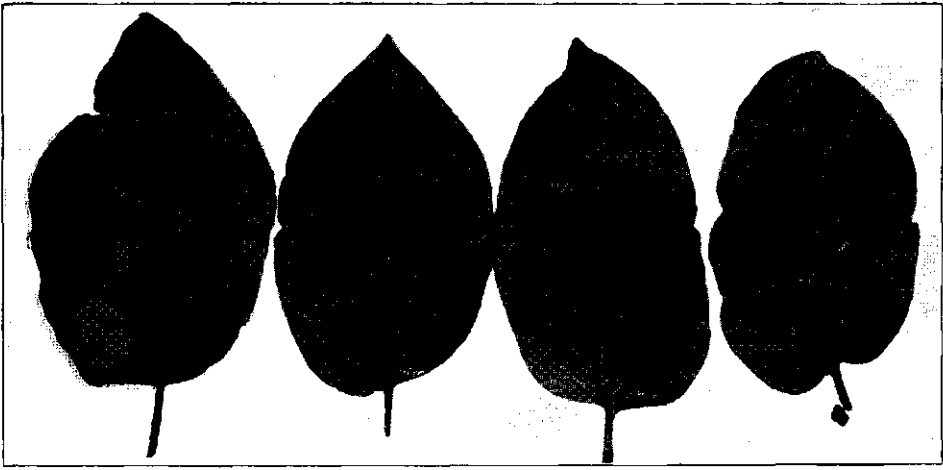


Fig. 1

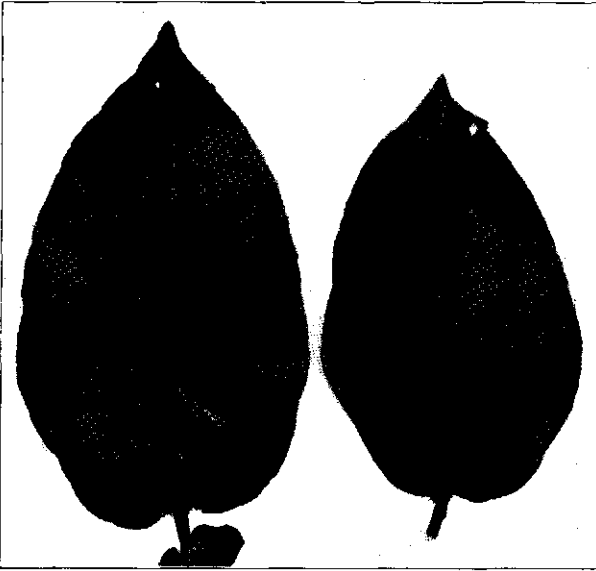


Fig. 2

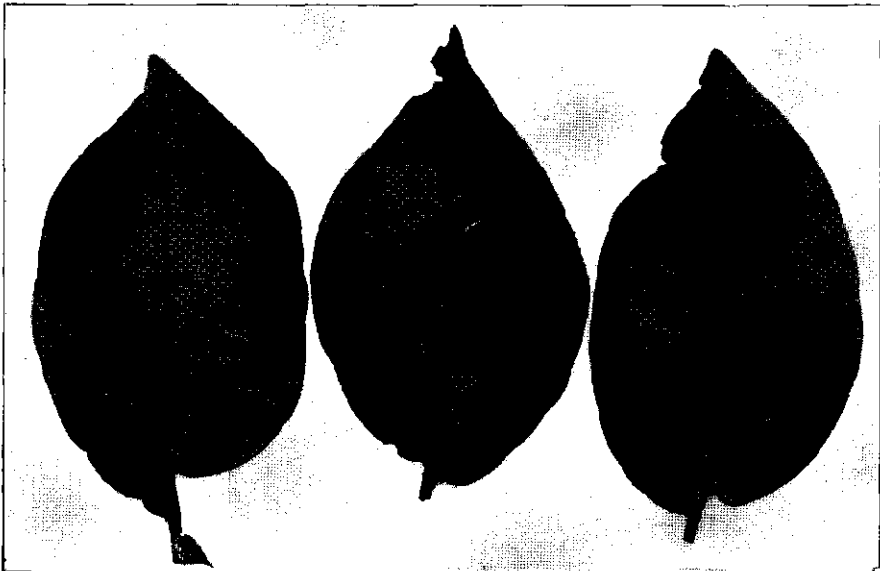


Fig. 3



Fig. 1

Fig. 2

Fig. 3

Fig. 4

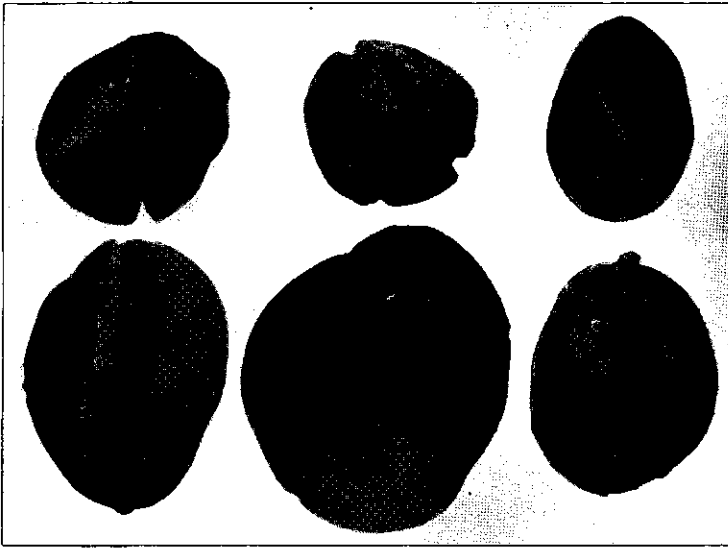


Fig. 1

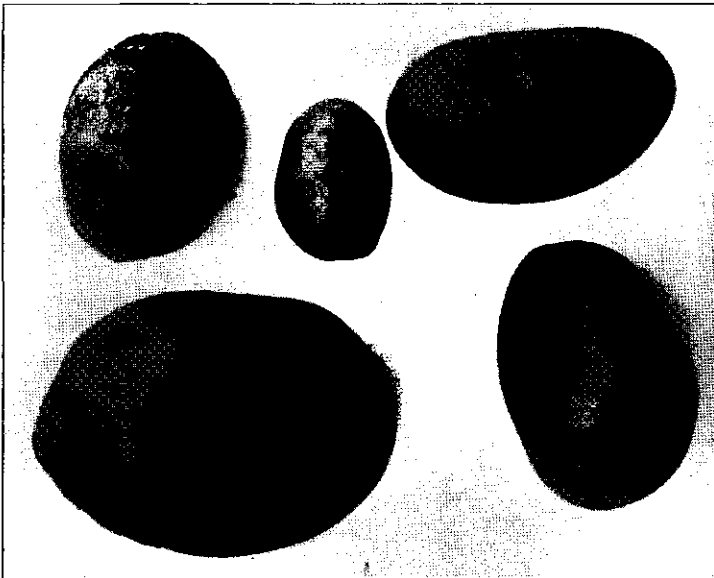


Fig. 2

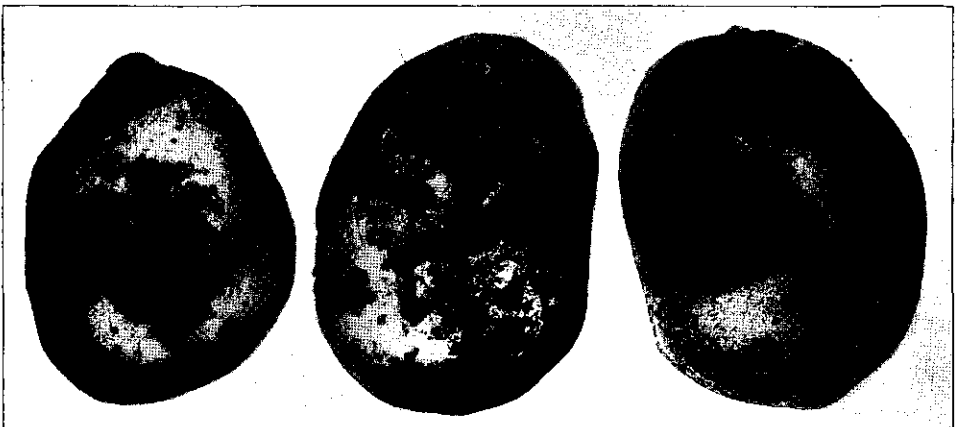


Fig. 3