

existence of natural spread may well prove an embarrassment in experimental work, and will certainly increase the difficulties of control.

#### DISCUSSION

RØNDE KRISTENSEN: showed some deformed apples of the Danish variety Gøldborg and asked whether these deformations are similar to those of green crinkle. They have been transmitted by grafting in Denmark.

*Answer:* The symptoms are quite similar to those of green crinkle on other varieties and so they may be caused by this virus.

POSNETTE: Does there exist, after the opinion of Dr ATKINSON, a possibility of seed transmission of the apple mosaic virus? It sometimes occurs that apple seedlings develop mosaic symptoms and seed transmission seems more likely than spread of the disease in the nursery.

*Answer:* There is not previously known any case of seed transmission of the apple mosaic. But in New Zealand the Jonathan variety contains for 100% a mild form of apple mosaic. Furthermore the English 'variegation' in the seedlings is quite similar to apple mosaic. So seed transmission might be a possibility.

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## FLAT LIMB (FUREDE GRENE) OF APPLE TREES

BY

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#### DISTRIBUTION IN VARIOUS COUNTRIES

Flat limb was mentioned in an Australian report (JAS. LANG) as early as 1905 but was then considered a purely genetical phenomenon. In 1907 the disease was reported from Connecticut (G. P. CLINTON) in U.S.A. and then supposed to be frost damage. Later on – in 1911-12 – another hypothesis was brought forward by Australian workers (D. MC. ALPIN), namely that flat limb was due to incompatibility between the rootstock and the scions of certain apple varieties. In 1938 workers in British Columbia (J. W. EASTHAM) believed that flat limb most probably is a virus disease, as no fungus or bacterium had been found in connection with the disease. From Italy flat limb is reported in 1941 (A. BIRAGHI) as a graft transmissible disease, which has been known in Italy for many years. A Californian report from 1942 (H. E. THOMAS) describes the disease as a virosis, which is graft transmissible to *Pyracantha* sp. From Nova Scotia in 1943 (J. F. HOCKEY) flat limb was described as very annoying in the apple variety Gravenstein. In one fruit farm the disease could have existed for at least 40 years. Investigations carried out in Nova Scotia show, that flat limb is transmitted with scions from infected trees, and the results indicate that symptom expressions are strongest on trees growing on rather weak rootstocks (E.M. IX). In the Nova Scotia report it is concluded, that if flat limb

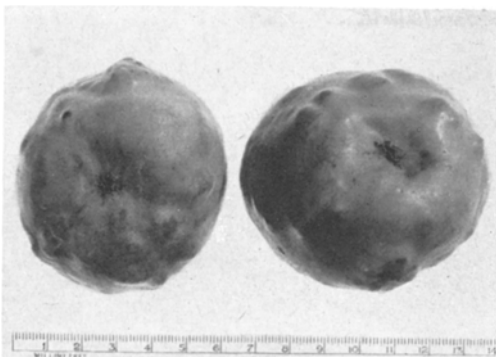


FIG. 1. Green crinkle on Sturmer apple; wart symptoms



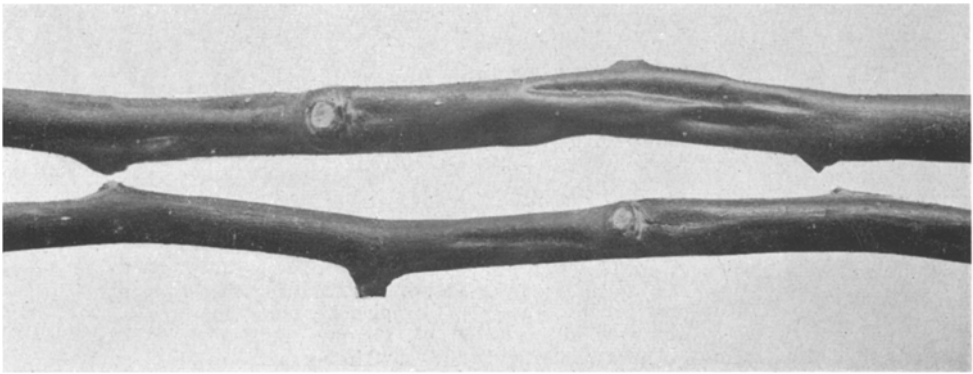
FIG. 2. Granny Smith apples showing severe symptoms of green crinkle



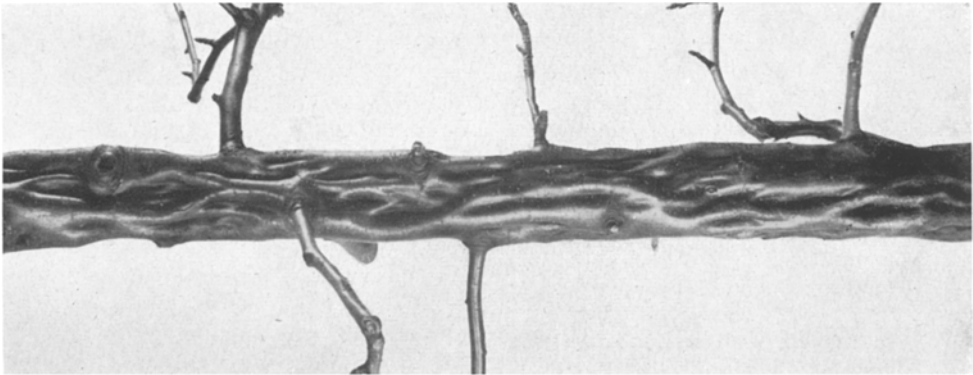
FIG. 3. Granny Smith apple with both concentric ring and russet symptoms of ring spot



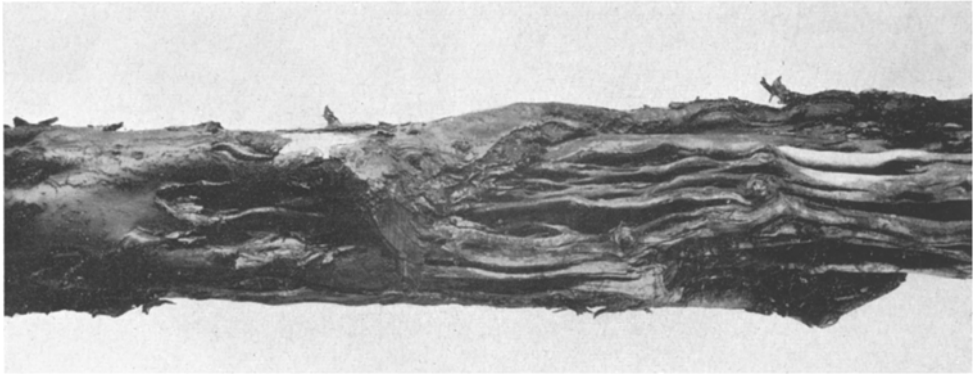
FIG. 4. Russet patches with brown margins beginning to form on a Granny Smith apple infected with ring spot



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FIG. 1. Flat limb in Gravenstein. Symptoms in one-year old shoots. FIG. 2. Flat limb in Gravenstein. Severe symptoms in seven-year old branch. FIG. 3. Flat limb in Gravenstein. Very severe symptoms in old branch. Necrosis and exposing of wood

is caused by a virus, it must be a very selective one, which only produces symptoms under special conditions.

In all the earlier reports concerning flat limb, the disease has only been mentioned in the variety Gravenstein; but in 1944 it was reported from England (WALLACE, SWARBRICK and OGILVIE), that flat limb was also seen in Lord Lambourne. In recent years the disease has been described in many European countries as occurring in several apple varieties. In Holland (personal information from D. MULDER) the phenomenon has occurred in the variety Signe Tillisch and in Sweden (D. LIHNELL 1949) flat limb has been observed in both Gravenstein and Signe Tillisch. The same two varieties together with Filippa and James Grieve have been reported from Norway as infected (T. RAMSFJELL 1950) and in 1952 the disease is described in Gravenstein and Signe Tillisch growing in the fruit district in Nether Elb in Germany (H. BÖMEKE).

#### DISTRIBUTION IN DENMARK

In Denmark flat limb was first described in 1940 (E. GRAM and A. WEBER), but diseased material was already delivered to 'The Danish State Experimental and Research Station for Plant Diseases and Pests' in 1936. Danish fruit growers claim to have seen the disease some 40 years ago, but then no one took any notice of these cases. Flat limb seems, however, to be much more widespread today and also the attacks seem much more serious than in earlier years. The disease is now to be found in many fruit farms all over the country, mainly in Gravenstein but also in some other apple varieties (Signe Tillisch, Filippa, Ildrød Pigeon, Dronning Louise, Rød Høst-Kalvil, Høve Reinet, James Grieve, Lord Lambourne, Lord Suffield, Guldborg and Rød Ananas).

Flat limb has been found in trees growing on various types of soils and also on many different rootstocks (E.M. IV, IX, XVI and apple seedlings).

In Denmark several theories concerning the cause of flat limb have been brought forward. At one time it was thought that the phenomenon might be due to excess of nitrogen and it has also been considered that lack of zinc or boron had something to do with the disease.

It is only some 10 years ago, that a virus was suspected to be the real cause, and the various investigations carried out since then, strongly support that view.

#### SYMPTOMS OF FLAT LIMB

The first external symptoms to be seen consist of a very weak flattening or slight linear depressions in the shoots or branches of infected trees. Later deep furrows occur, or the branches may be completely flattened out and very often much twisted. At the same time necrosis develops on the diseased branches, which become very weak and brittle. In several cases the symptoms are only to be seen in the older branches, but symptoms have also occurred in the very young shoots – in some cases even in the current years growth. The effect of the disease varies considerably. On some infected trees the damage – if any – is very slight and the symptoms are hardly visible. In other cases, infected trees are severely damaged and almost completely ruined.

Sometimes the symptoms can be seen while the trees are very young, and now and then even in the nurseries. But mostly infected trees first show signs

of the disease, when planted out in the fruit farm, and in some cases several years may pass before any symptoms occur.

These facts can explain, why several fruit growers often declare, that flat limb is spreading in the fruit farms. Most probably the elder trees, which show symptoms of the disease, have already been infected in the nursery. It is not yet known what conditions conduct the speed of and the whole development of the symptoms, but several factors may play a role. It is likely, that the virus in question occurs in several strains, some of which are weak, while other are very severe. The rootstock may also have some influence, and conditions which favour vigorous growth also seem to strengthen the symptoms of flat limb.

#### DANISH INVESTIGATIONS CONCERNING FLAT LIMB

Since 1948 various grafting experiments concerning flat limb have been carried out in Denmark.

These experiments can be divided into five groups:

- I. In the first group, scions from healthy Gravenstein-trees have been grafted into infected trees of the same variety.  
Four years after the grafting 22 trees out of 27 showed symptoms of flat limb in the growth from the inserted scions, and in two of the trees, the symptoms occurred already in the current years growth – in the year of grafting (eight months after the grafting).
- II. In the second group, scions from diseased Gravenstein-trees were grafted into healthy trees of 12 different apple varieties.  
Five years after the grafting 37 of 44 trees showed symptoms of flat limb in the growth from the inserted scions, but in no case could any symptoms be observed in any of the grafted trees, even though some of the varieties are susceptible to flat limb. Apparently no downward movement of the virus takes place.
- III. In the third group, scions from healthy trees of 10 different varieties were grafted into diseased Gravenstein-trees, but the disease – or to be correct the symptoms – were only transmitted to two varieties, namely Red Pigeon and the Danish variety Bodil Neergaard.
- IV. In the fourth group healthy scions of Gravenstein were topgrafted into symptomless branches of the Danish varieties Høve Reinnet and Ingrid Marie, which some years earlier had been grafted on diseased Gravenstein-trees.  
The topgrafted Gravenstein showed symptoms of flat limb on a few trees of both varieties – in Ingrid Marie already one year after the topgrafting.
- V. In the fifth group some 30 E.M. IX rootstocks were budded with material from infected Gravenstein-trees. The following year symptoms were observed in 23 of the young trees.

#### CONCLUSIONS

The experiments clearly show, that flat limb is a graft-transmissible disease.

The experiments also demonstrate, that there is a great difference between the susceptibility of the various apple varieties, and furthermore that some varieties can act as symptomless carriers.

As it is rather difficult or impossible to remove all infected trees in the nurseries by inspection and roguing, steps have been taken to establish a nucleus stock of all important apple varieties, from which the nurseries can be supplied with grafting and budding material.

Important questions concerning flat limb, which are not yet solved, are a further search for symptomless carriers among the important apple varieties and also among the apple rootstocks.

Furthermore it would be of value to know the exact effect of the disease on growth and fruit production of the infected trees. Experiments concerning these problems are now in progress.

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#### DISCUSSION

SCARAMUZZI: Since the symptoms of psorosis in Citrus are very similar to those of flat limb in apples will it not be better to replace the name psorosis in Citrus by flat limb?

Answer: Similarity of symptoms in different plants is not a reason for giving the same name and this is even undesirable because of the probability of two viruses being involved.

THUNG: Is there an insect vector known?

Answer: Some years ago it has been tried to transmit the disease by aphids, but these trials had no result.

BLUMER: After Swiss experience flat limb diseased trees often give a very good yield. So the growers are sceptical about the damage caused by this virus. Are there details available about the Danish experience on this matter?

Answer: In some cases there are only very few symptoms and then the yield is good, but in other cases there is much reduction in the crop.

The deformation of the crowns of the trees is the most important result of

flat limb. The yield may be good but it is impossible to grow a well shaped tree. So the growers will eradicate such trees even if the yield may not be influenced so much (THIEM).

In New Zealand flat limb causes serious losses in the Gravenstein variety as branches showing severe symptoms stop growing and the fruits become small and rough (ATKINSON).

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## ROUGH SKIN OF APPLES<sup>1)</sup>

BY

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In contrast to the situation in stone fruits of which already a large number of virus symptoms is known, in apples and pears only few virus diseases have been found. In Holland some of these virus diseases occur.

Symptoms of unknown cause on the fruits of apple trees of the varieties Belle de Boskoop and Glorie van Holland in scattered orchards were found in the Netherlands several years ago. These symptoms which are generally well defined concern a roughening of small or larger parts of the skin of the fruits and cause serious losses.

Rough corky brown patches develop on the skin of the fruits. Sometimes these patches are small and have a somewhat circular shape. In other cases rough brown rings or elongated stripes can be seen, whilst the fruits of heavily infected trees often show a roughening of large parts of the skin. It has been observed that in some cases the rough brown patches are cracked and the fruits may show a slight deformation due to local growth retardation. The patches develop both in the green and coloured parts of the skin.

The symptoms mentioned occur first on the fruits of one or some branches of an infected tree, but gradually they appear also on the fruits of other branches and finally they can be found over the entire crown. The number of affected fruits of a tree increases rather rapidly within a few years.

Fruitgrowers have observed that the number of infected trees in orchards also increases during a period of several years. For that purpose one fruitgrower kept apart the apples of each Boskoop tree in his orchard during picking time and sorted them out on rough skin symptoms. From these observations it has become likely that there is also a spread of the disease from tree to tree. However it is not yet known whether this spread takes place in a natural or artificial way.

This disease, which in the Netherlands is called 'ruwschilligheid', meaning 'rough skin', causes heavy losses. The growth of the fruits of infected trees is retarded and in consequence these fruits remain smaller. Affected fruits can be sorted only in the lowest commercial grades and have only little market value.

The rough skin symptoms can already be found soon after the first development of the fruits. In our country the disease is only found in older trees.

As was said before mainly the apple varieties Belle de Boskoop and Glorie

<sup>1)</sup> Photos of the symptoms have been published in Tijdschr. o. Plantenz. 61:4-6 (1955).