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A METHOD FOR DETERMINING THE RESISTANCE TO SNOW MOLD (*FUSARIUM NIVALE*) IN WINTER CEREALS ESPECIALLY AT PLANT BREEDING STATIONS

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SELOSTUS:

MENETELMÄ SYYSVILJALAJIKKEIDEN LUMIHOMEEN(*FUSARIUM NIVALE*)-KESTÄVYYDEN TUTKIMISEKSI ERIKOISESTI KASVINJALOSTUSLAITOKSILLA

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Introduction

It is known that pathogenic winter fungi are among the most serious factors causing damages to the stands of winter cereals and grass crops in regions with long and snowy winters. In Scandinavia Ekstrand (1955) has drawn particular attention to the dangers of winter fungi on overwintering crops, especially winter cereals and pasture crops. He has also emphasised the importance of introducing varieties resistant to these fungi. Observations and investigations made by Nilsson (1941) show clearly that winter fungi affect the cultivation of winter rye in central and northern Sweden. Nilsson has also emphasised the importace of breeding winter fungi-resistant varieties for these areas. Larsson (1961) in Sweden has recently discussed the influence of the parasitic winter fungi in damages to overwintering cereals. In Finland plant breeders (Pohjanheimo 1946, 1959, Valle 1947, Pesola 1953, Linja-aho 1955) and especially plant pathologists (Jamalainen 1961) are by now aware of the fact that the part played by pathogenic winter fungi as sources of damage in the overwintering of winter cereals among others is considerable, and that in plant breeding efforts should be made to develop material that would be resistant to these fungi.

Anyhow, in so far as the present writer knows, none of the plant breeding stations in Scandinavia have carried out systematic studies with regard to the resistance to winter fungi in the breeding material, by applying artificial infection and under artificial environmental conditions equalling those under the snow. Frandzen (1946) has applied a method that has proved suitable in breeding clover material resistant to *Sclerotinia trifoliorum.* A corresponding method for breeding winter cereals resistant to smow mold *Fusarium nivale* or to other pathogenic winter fungi has, however, not been known.

Regarding investigations carried out outside Scandinavia concerning the resistance to snow mold in strains and varieties of winter cereals only those of Pichler (1953, 1957) shall be mentioned here. They besides the publications of Jamalainen (1961) cover the most important results concering the methods of testing published so far as well as the possibilities of controlling the damages caused by snow mold. Pichler has recommended the cultivation of seed grain in so called infection areas (Infektionsgebiete) and testing in areas where the seedborne infection causes considerable damage to the stands (Befallsgebiete). The latter are 'as a rule' also infection areas.

The present author has been studying the problems of overwintering since 1945. First I have tried to find methods which would promote the introduction or development of new varieties of winter cereals overwintering succesfully under Finnish environmental conditions (POHJANHEIMO 1959). Then I have also made efforts to solve the problem of the relation between shortness of straw and poor overwintering in the breeding material of rye (VIRTANEN 1955, POHJANHEIMO 1956). The writer has tested a method of a sowing rate heavier than normal in order to determine in this way the varietal differences concerning the effect of the winter fungi. This method, together with the method of sowing whole axes of pedigree material, increases the possibilities for a first thinning out of the selection material. The amount and the effect of the winter fungi vary, however, considerably under different winters. Nor is the degree of infection in the material uniform. The seed grains or axes that have not been infected give stands which will survive better than those developed from infected seed. Thus we may find some overwintered plants or plant groups the resistance of which against snow mold has not been tested.

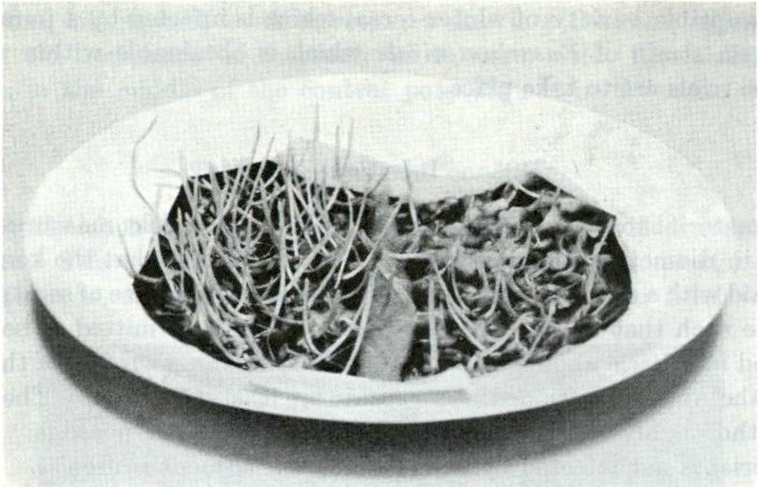
The author has therefore tried to find a method that would be of use in testing the resistance to snow mold in winter cereals at an early stage, when there is only little seed, i.e. in as early a stage of breeding as possible. This would also enable investigations to be carried out every year in a way in which the other varying factors would not have a disturbing influence on the results. This idea gave rise to a laboratory method of testing the material under artificially controlled environmental conditions.

After many tests I have reached the following method which has been found suitable in studying the resistance to snow mold in winter cereals.

Method for studying the resistance to snow mold (*Fusarium nivale* [Fr.] Ces.) in winter cereals.

Material

The fundamental fact in the author's method is that the infection is introduced by living plants. The infection is, further, introduced in such a way that the snow mold grows from the underground parts of diseased plants to the healthy



1. Kernels of rye which have germinated in dark at +5° to +7°C, on blotting paper soaked in 0.02 per cent solution of maleic hydrazin. To the left, kernels not infected by snow mold. (Photo by O. Inkilä)

ones which are to be tested. In this way we accomplish a lasting, continual infection. This method also allows a treatment which does not disturb the natural resistance of the plants.

Seed of winter rye proved to be heavily infected by snow mold has been used as source of infection. In order to obtain such material tests with disinfected and untreated seed either in the field or in a laboratory are required. The author has noticed that in order to promote the selection of suitable material infected by snow mold, for example maleic hydrazin can be applied. As an anti-auxin it does promote the growth of snow mold in young plants growing from infected seed. This substance probably reduces the inhibiting effect of the auxin of young plants upon the growth of snow mold-mycelium. The author has kept the seed germinating at +5° to +7°C and in a dark room on a blotting-paper soaked in a 0.02 per cent solution of maleic hydrazin. LEOPOLD and KLEIN (1952), among others have carried out investigations concerning the effect of maleic hydrazin. The present author has applied those investigations in order to establish a seed-borne infection of snow mold. (Fig. 1).

Seed to be used as a source of infection is chosen among the varieties which are commonly grown in the area concerned in order to avoid such strains of the fungus that are uncommon and less damaging in the local conditions. As infective material it is also possible to use seed of a snow mold-susceptible variety of winter cereal which is infected by a pure culture of a certain strain of *Fusarium nivale* which is obtainable within the area where the trials are to take place.

Infection

The material to be tested is sown for example in crocks measuring about 5 inches in diameters. The crocks are filled with soil so that the kernels can be overlaid with a sandcovering about one inch deep. The size of sand granules should be such that an even penetration of water is permitted. The kernels are placed in a circle about 2 centimeters from the inner surface of the crock. Pots of the above mentioned size contain at least 15 kernels. The seed is treated thoroughly with a as effective disinfectant as possible. In case the material is not infected by snow mold its treatment is useless.

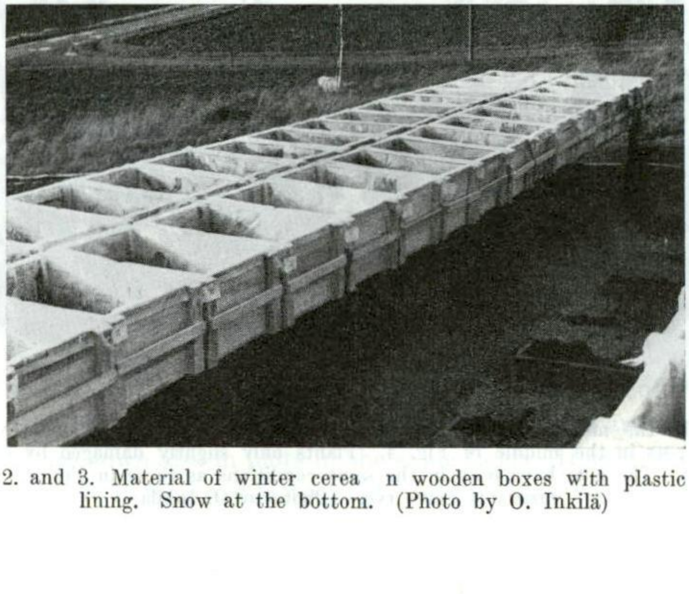
Kernels which will be used as source of infection, 10—15 in number, are placed in the middle of the crock. They are sown in a single group. The number of kernels is dependent on the degree of infection and on their germinating power. These kernels are not treated with a disinfectant. In the middle of the control pots are sown the non-infected kernels or healthy treated material of the same variety and as many germinating kernels as exist in the source of infection. Crocks without seedlings in the center will serve equally well as controls. The pots are then kept under local natural environmental conditions. When necessary it is also possible to grow the material under artificially forced controlled conditions, where the seedlings can develop about the same degree of hardiness as they would in the field. The material must be sheltered against cold and insects as well as against other disturbing factors.

At the beginning of the winter, or as soon as the material otherwise has reached a suitable phase of development, the crocks are placed in a dark place where the humidity is as high as possible (95—100 per cent) and the temperature is about 0°C (0—+1°). These are the conditions that prevail under the snowcovering and where the resistance to snow mold in winter cereals is to be tested.

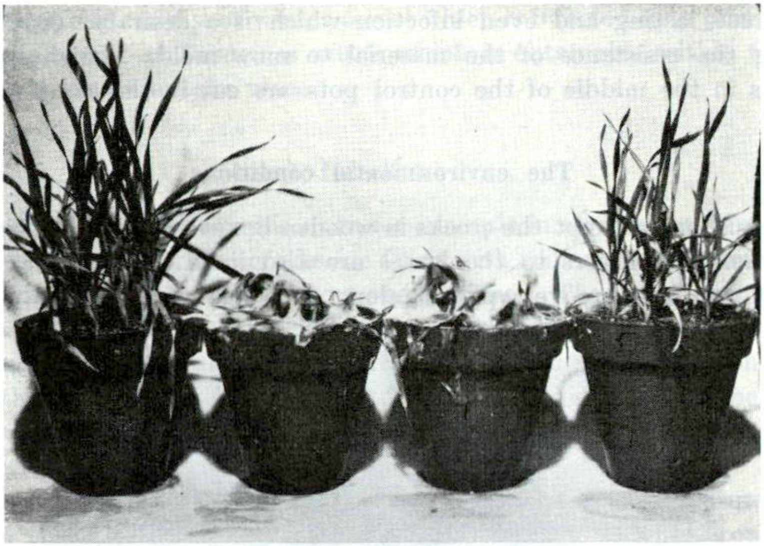
Just before placing the crocks in the dark a step is taken which will promote the growth of snow mold in the source of infection and influence the uniformity and effectiveness of the infection. The group of seedlings that has emerged in the middle of the crok from the untreated, snow mold infected kernels is cut at sand level. In this way the parts of the seedlings above sand level in the infection group are eliminated. This serves to promote the growth of snow mold in the underground parts of this seedling group. From the underground parts of these seedlings the mycelium does grow to the adjacent seedlings which are to be tested. Thus here is provided a continual, lasting and even infection which is a desirable condition for studying the resistance of the material to snow mold. The shoots of the seedlings in the middle of the control pots are cut in the same way.

The environmental conditions

The author has kept the crocks in wooden boxes provided with a plastic membrane. The covers to the boxes are also lined with plastic. A strip of vinylfoam is, moreover, placed along the edge of the lid in order to



2. and 3. Material of winter cerea n wooden boxes with plastic lining. Snow at the bottom. (Photo by O. Inkilä)



4. In the middle two crocks with plants damaged by snow mold. On either sides healthy plants in pots which have not been infected. The variety is Kungsråg II. (Photo by O. Inkilä)

5. In the middle two crocks infected by snow mold in the same way as the pots in the middle of Fig. 4. Plants only slightly damaged by snow mold. The pots have been in the same conditions as those in Fig. 4. The variety is Toivo rye. (Photo by O. Inkilä)

tighten the covering. Snow is placed at the bottom of the boxes. In case no snow has been available, crushed ice and a little water has been used (Fig. 2 and 3). In this way the relative moisture of the air is kept high and the temperature even. The material has been kept in a room furnished with refrigerating equipment. The temperature of the room has been kept at about 0° to +1°C. The author has also used this method in studying the rate of speed at which snow mold damages the plants at different temperatures.

Figures 4 and 5 show the results of a trial that lasted for 2 ½ months at 0° to +1°. The infected seedlings of one variety, viz. Svalöv's Kungsråg II, (King's rye II), have been almost entirely damaged, while another variety, viz. the Finnish variety Toivo rye, has been damaged only to a small extent. Snow mold occurs, however, also in these plants. Non-infected plants of both varieties have not been damaged under the same conditions

Applications of the method

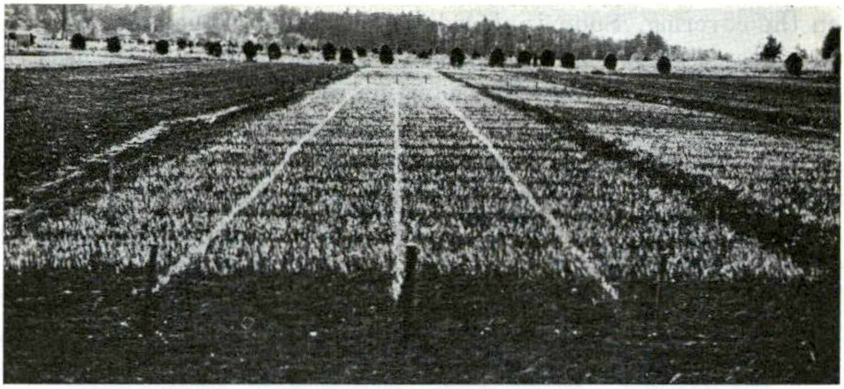
The method of infection discussed above can also be applied in field e.g. in the following way.

The material to be tested is sown in the usual way in plots. In rows at right angles to these rows is sown at suitable distances (50—100 cm) untreated seed infected with snow mold (Fig. 6). The seedlings in these rows are cut before the lasting snowcovering forms.

If it is necessary to economise with the seed of the infected material one can also sow only small groups of it at certain distances in the same rows in which the seeds of the variety to be tested are sown. The resistance to snow mold in the varieties to be tested can be graded in spring according to the amount of damaged plants, according to the width of the belts of damaged plants.

To the knowledge of the author, no investigations concerning the importance of soil infection in different parts of a country have been carried out in Scandinavia (cf Elomaa 1952, p. 33). The method discussed above may prove suitable also for such a plan. It should be possible to establish the source of infection for example in the following way.

So-called indicating plots are sown in different parts of the area concerned (country or geographical area) or in fields subjected to different cultivation measures. Some of the plots are sown with seed not infected by snow mold, or from which the snow mold has been absolutely removed. Other plots are infected by the above described method. Seeds which are used, as infective material are sown also in plots in the same fields. If suitable species and varieties are used it is possible to study in this way the development of



6. A trial in which three rows have been sown across the plots. These three rows function as infection sources. (Photo by O. Pohjanheimo).

the snow mold and the way it damages the plants in the local conditions, as well as the influence of soil infection in the areas concerned. If snow mold damages plants only in the infected plots and in plots sown with infected seed, it goes to show that damage is primarily due to infection from the seed. If, moreover, the stands, not artificially infected which developed from kernels free from seed-borne infection are damaged, soil-infection or an infection other than a seedborne one, is indicated. If snow mold does not occur in any of the plots it proves that snow mold has not been able to grow and cause damage under the prevailing conditions. By choosing indicating varieties carefully it is possible to obtain information about the relative importance of snow mold in relation to the other parasitic winter fungi. This method thus provides remarkable possibilities for studying things which are at present rather inadequately known in Scandinavia. The susceptibility of plants to snow mold and the resistance to damages caused by snow mold within different regions and under different measures of cultivation is an interesting and important subject for further investigation. Obviously the climatic conditions and cultivation methods in different districts and on different soils produces a certain microflora in the soil. This microflora may act as a more or less effective protecting shelter against certain winter fungi. Moreover, the type of soil apparently has a distinct influence in the spreading of snow mold. The above method may prove applicable also in the study of these problems.

Selostus

Menetelmä syysviljalajikkeiden lumihomeen(Fusarium nivale)-kestävyyden tutkimiseksi erikoisesti kasvinjalostuslaitoksilla.

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Kirjoittaja selostaa menetelmän, jota hän on käyttänyt tutkiessaan syysviljalajikkeiden ja -kantojen kestävyyttä lumihometta vastaan. Tutkimukset on suoritettu keinollisesti hallituissa oloissa, jotka vastaavat niitä, mitkä vallitsevat lumipeitteen alla maan ollessa roudaton tai vain vähän roudassa.

Tartunnan lähteenä on käytetty lumihomeen saastuttamia syysviljan siemeneriä ja näistä kehittyneitä taimiryhmiä. Lumihomeen kasvua viimeksi mainituissa ja leviämistä niistä tutkittaviin oraisiin on edistetty heikentämällä tartunnan lähteenä olevien taimien vastustuskykyä poistamalla niiden maanpäälliset osat sekä järjestämällä kasvualusta lumihomeen leviämiselle suotuisaksi.

Tartunnan lähteinä käytettävien siemenerien etsimisessä on maleinihydratsini osoittautunut soveliaaksi, itävien siementen ja nuorien taimien vastustuskykyä lumihometta vastaan heikentäväksi aineeksi. Tämän aineen hyväksi käyttöön ovat antaneet aiheen tutkimukset (mm. Leopold & Klein 1952), jotka ovat osoittaneet ko. aineen vaikuttavan antiauksinina.

Kirjoituksessa selostetaan edelleen menetelmän hyväksikäyttöä koekentillä syysviljalajikkeiden ja -kantojen lumihomeenkestävyyden tutkimiseksi. Lopuksi viitataan mahdollisuuksiin, joita menetelmä tarjonnee tutkittaessa lumihomeen esiintymistä ja vahingollisuutta erilaisissa viljelyoloissa, ilmastollisesti ja maaperällisesti erilaisilla alueilla sekä tutkittaessa erilaisten viljelyteknillisten seikkojen (kasvinvuorottelu, lannoitus ym.) vaikutusta lumihomeen esiintymiseen ja sen aikaansaamiin vaurioihin sekä ns. maasaastunnan, välittömästi maasta lähtöisin olevan tartunnan suhteellista merkitystä.

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