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BLIND SEED DISEASE OF RYEGRASS IN THE NETHERLANDS[1]

Blinde-zadenziekte van raaigras in Nederland

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The blind seed disease of ryegrass, caused by the fungus *Gloeotinia temulenta*, is always present but seldom becoming important in the Netherlands. In 1965, however, probably due to a very rainy summer, it developed epiphytotically especially in the awned ryegrasses, Italian and Westerwold. With the waterdrop method an average seed infection of 19.2% was observed. Westerwold ryegrass was more strongly infected than Italian, and tetraploids heavier than diploids. The disease was most prevalent in the coastal provinces, petering out towards the South-East. In samples of the 1964 and earlier harvests the fungus was also found, although it seldom reached high percentages. The relationship between infection percentage and germinating capacity percentage of the samples was approximately a 45° one, the correlation coefficient between both values being 0.77. Extra cleaning of seed samples did not influence their infection percentages. In experiments on seed treatment the agar method was used for determining viable infection. The hot water method with 30 minutes at 50°C as indicated by Irish workers, as well as the mercurial treatment in combination with heat advocated in Scotland, appeared to leave part of the infection surviving. A warm water treatment with 2–2½ hours at 45°–46°C, however, proved to be very satisfactory by totally eradicating the infection without injuring the seed.

INTRODUCTION

In the past the blind seed disease of ryegrass, caused by the fungus *Gloeotinia temulenta* (Prill. & Del.) Wilson, Noble & Gray, was present but it seldom caused any serious difficulties in Holland (DE TEMPE, 1950). The author has the impression that in more recent years it has gained in importance in the country. In the 1965 crop it reached epiphytotic proportions, though only in the awned ryegrasses, Italian and Westerwold. This may be attributed to the extremely rainy summer of that year.

The investigations presented in this publication were started after a chance remark, overheard at a seed firm, regarding the difficulties offered by the awned ryegrasses of the new harvest as to their germinating capacity. Back in the Seed Testing Station the cause of the complaint was soon proved to be an exceptionally strong infection by the blind seed fungus.

The investigations consisted of two main parts. The first part was a survey in order to determine the extent of the disease; the second phase consisted of a series of experiments on control of the seed-borne infection.

MATERIAL AND METHODS

A wealth of material for investigation was available in the Seed Testing Station in the form of contract samples. These are samples from lots grown in

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contract by farmers for seed firms. Uncleaned samples taken directly after threshing are sent to the Government Seed Testing Station for determining the percentages of debris, moisture, purity and germination, on the basis of which the farmer will be paid by the firm. A seed health test is normally not made for these samples. However, the samples were available for health inspection.

Therefore, several hundreds of samples of Italian and Westerwold ryegrasses *(Lolium multiflorum)*, tetraploids as well as diploids, were analyzed and in addition a number of samples of English ryegrass *(Lolium perenne)* were tested. For this survey the waterdrop method as described by CALVERT & MUSKETT (1945) was used. In this method a certain number of seeds (in our case 100) per sample are placed each in a drop of water on a glass plate, the glumes are loosened from the seeds with a pair of needles, and then the drops are examined at a 100× magnification for the honeydew spores (conidia) of the fungus. This is a reliable method although some doubt exists as to the number of spores that may be regarded to be sufficient to indicate whether a seed is infected, but usually the spores occur in great quantities. When in the early summer of 1966 a series of samples was forwarded to an Northern-Irish investigator, the latter using the waterdrop method found infection percentages about two thirds as high as had been found at the Wageningen Station.

Since this method is both tedious and time-consuming the spore count method of HARDISON (1963) was tried. In that method a certain quantity of seed is shaken with an equal volume of water, the water is drained off to remove the seeds, and a spore count in a blood counting chamber is made in the resulting suspension. However, with low infection percentages according to the waterdrop method the number of spores counted with HARDISON's method were so low, that in these cases the method was concluded to be insufficiently accurate. Increasing the spore number by concentrating the suspension was impossible as the corresponding increase of dirt particles prevented an accurate count. So, this method was soon dropped.

For the determination of surviving infection in seed treatment experiments the waterdrop method is not suitable because the procedure is based on the observation of the short-lived conidia and is not a vitality test for the fungus. For that purpose the agar method as developed by CALVERT & MUSKETT (1945) was used, viz. removing the glumes from the seeds, surface-treating them in 0.1% mercuric bichloride solution for 5 minutes, cutting them lenghtwise and plating the halved seeds with the cut surface down on malt agar. After two weeks at room temperature in darkness the slimy whitish colonies of the fungus have sufficiently developed for recognition. Eventually they may be checked for the presence of *Gloeotinia* spores by investigating a microscopic preparation.

Some experiments were made using an alternative viability test, viz. sowing the infected samples in either silversand or natural soil and observing the formation of apothecia. The boxes were placed at temperatures of 12° and 17°C under fluorescent daylight lamps. Apothecia did appear but very slowly and irregularly, so that after several months the percentages of seeds having produced apothecia were far below the probable infection percentages of the samples. Consequently, this method was considered not applicable as a quantitative viability test and was discarded.

The germinating capacity of many samples, including those that had been

subjected to a treatment for controlling the seed-borne infection, was determined. This was done on moist blotters under Copenhagen belljars, starting with five days prechilling at 10°C for afterripening, and then germinating for nine days at alternatingly 30°C with fluorescent light during the working day and 20°C without artificial light during the remainder of the 24 hours. Percentages of normal seedlings were determined with a first count after five days of germination and the final count after nine days, starting with 400 seeds.

With 30 samples from different seed treatment experiments a soil test was made using sandy soil and a constant temperature of 12°C. The average emergence percentage was only slightly lower than the germinating capacity (68 and 75%, respectively). Consequently any weakening of owned ryegrass by seed treatments is sufficiently expressed in the official germination percentage determined under favourable conditions of germination.

RESULTS

The results of the survey

Several questions may be asked in connection with the alarming situation concerning this disease in 1965. First, that about its occurrence in different parts of the country. Second, that of the occurrence of the disease in different species and ploidal forms of ryegrass. Third, that regarding the infection in seed lots to be used for further seed production. Lastly, that of the relation between seed-borne infection and germinating capacity of the seed.

Close to 400 samples of the 1965 crop were inspected with the water drop method, using a severe judgment in which already the presence of a few spores was accepted as prove of a seed being infected. A number of the samples were tested because of insufficient performance in the official germination test. However, a number of 221 arbitrarily chosen samples showed from 0 to 94% infection with an average of 19.2%.

A number of 374 samples were arranged according to the producing district, with the following averages of infection resulting:

	Number of samples	Average infection %
North-Holland	34	37½
Groningen, sea silts	141	25
Groningen, peat soils	14	24
North-Brabant	33	21
North-East Polder	9	20
Zealand	77	18½
South-Holland	28	12
Guelderland	12	10
Overyssel	3	5
Limburg	23	2½

There is a tendency towards lower infection averages for the districts where – may-be for good reasons – less ryegrass seed is raised.

When grouped as to type of ryegrass, 374 samples gave the following averages:

	Number of samples	Disease %	Germination %
Italian diploid	43	12.6	84.9
Italian tetraploid	140	21.2	76.2
Westerwold diploid	117	20.2	78.6
Westerwold tetraploid	74	28.7	73.4

These numbers of samples and corresponding infection and germination levels are sufficient for considering the differences important, notwithstanding the fact that the figures for individual samples are based on 100 seeds only.

In as much as most publications on blind seed disease are concerned with perennial ryegrass it would also seem advisable to inspect a number of perennial ryegrass samples, even if few complaints about insufficient germination were raised for this species. In 135 miscellaneous commercial samples of perennial ryegrass seed an average infection of slightly less than 1.5% was found, although with a maximum of 18%. In a series of 21 contract-grown samples of the 1965 crop an average of 4.6 and a maximum of 24% was observed. Apparently this crop largely escaped the disease, whereas the awned species were strongly infected notwithstanding the widely different growing conditions of Italian and Westerwold. The former is mostly sown the previous year, may be cut in fall and is cut in spring, and only then is used for seed production. The latter type is normally sown in spring, often late when filling in a gap after the failure of another crop, and is used for seed production in the same year.

Sixty four samples from seed lots intended for further seed production (elite lots) were investigated and the following results were obtained using 200 seeds per sample:

Infection percentage	Number of samples	Infection percentage	Number of samples	Infection percentage	Number of samples
0	9	12	2		
1	10	13	0	24	1
2	10	14	1	25	1
3	1	15	1	26	2
4	0	16	0	27	0
5	5	17	0	28	0
6	1	18	0	29	0
7	0	19	3	30	1
8	1	20	1	31	2
9	0	21	2	38	1
10	6	22	1		
11	1	23	0	58	1

Taking into consideration that the 64 lots comprise four types of ryegrass and are owned by a number of seed firms, the above list does not offer the possibility of choosing only infection-free or slightly infected seed lots for propagation.

In this connection it seemed worthwhile to examine some samples of earlier years. It was possible to obtain 40 awned ryegrass samples of the 1964 harvest and in addition 11 of earlier harvest years. With investigation of 200 seeds per sample in the waterdrop method these gave the following infection percentages:

Infection percentage	Number of samples		Infection percentage	Number of samples	
	1964	earlier		1964	earlier
0	4	2	11	1	1
1	6	5			
2	11	1	13	1	0
3	1	0			
4	2	0	16	1	0
5	2	1	18	1	0
6	1	0			
7	0	0	28	1	0
8	4	0	30	1	0
9	0	1			
10	2	0	47	1	0

This creates the impression that in recent years, most of which were more rainy than normal, the disease has gradually built up. The very wet summer of 1965 resulted in a strong increase.

However, already a small seed-borne infection no doubt can cause a strong disease development in the field. The primary infection brought about by ascospores discharged by the apothecia reaching the ryegrass flowers may be slight, but still the secondary infection caused by the horizontal spread of honeydew spores may be strong. This opinion was substantiated by examining the progeny of several 1964 seed lots, and comparing the infection percentages of the parent seed lots with those of the derived seed lots. The results are given below.

Infection in parent seed 1964 %	Infection in offspring samples 1965			
	Number of lots	Minimum infection %	Maximum infection %	Average infection %
1	15	5	94	29
1	14	6	76	29
1	14	5	61	29
1	11	2	82	23
2	17	0	75	22
2	15	1	35	14
8	22	2	82	30
9	6	0	38	19
10	8	8	58	39
28	4	19	59	32

This clearly illustrates the great influence of field conditions on disease development, the size of the infection in the seed sown being a subordinate factor. After sowing seed with 8 or 9% infection it was possible even in 1965 to harvest seed with only a trace of infection. On the other hand, after sowing seed with a trace of infection it was possible to harvest seed with more than 90% of the disease. The average infection in the seed sown of the above listing was 6.3% and that in the seed harvested amounted to 26.7% which is more than four times as much.

The relationship between infection and germinating capacity was studied in

342 seed samples (not forming a representative collection). The correlation coefficient between the two was found to be 0.77 notwithstanding the fact that some samples were nearly free from infection and yet had a very low germinating capacity (probably in consequence of delay in drying). This means that the blind seed disease was responsible for nearly two thirds of the low germination level of the seed. When the germinating capacity of the samples was plotted against the infection percentage an approximately 45° line could be drawn through the cloud of dots. The width of this cloud will be partly due to the fact that only 100 seeds per sample were used for determining the infection percentages.

The effect of seed cleaning on the infection

When a contract sample shows an unsatisfactory germination result in the Seed Testing Station, it is normally returned to the Cleaning Division and subjected to an extra cleaning. This is done with the purpose of increasing germinating capacity of the seed at the expense of losing a certain quantity of seed. In case of insufficiently germinating ryegrass samples this extra cleaning rarely results in an improvement. This experience was corroborated with an experiment made for the purpose of reducing infection by blowing out an additional quantity of light seeds with a clipper machine. The results obtained are as follows:

Sample No.	Kind of seed	Additional seed removed %	Infection %	Germination %
1	Italian tetraploid	–	20	76
		10	25	74
		20	26	81
2	Westerwold diploid	–	26	81
		10	34	86
		20	28	86
		30	26	86
3	Italian diploid	–	24	78
		10	24	81
		20	35	76
		30	30	67
4	Italian tetraploid	–	39	45
		10	44	53
		20	56	52
		30	53	51
		40	51	53
5	Westerwold tetraploid	–	44	67
		10	37	75
		20	32	70
		30	32	75
		40	30	76
6	Westerwold tetraploid	–	33	66
		10	38	67
		20	31	75
		30	22	79
		40	31	79

Apparently additional cleaning did not improve the quality of the seed. The erratic differences in the above table may be explained from the error of the experiment.

In another experiment the already cleaned samples were passed over a paddy table, and the fractions were analyzed. The figures obtained with the undivided samples as well as with their three fractions are presented below.

Sample No.	Kind of seed	Fraction No.	Infection %	Germination %
1	Westerwold diploid	–	14	84
		I	15	78
		II	22	90
		III	13	83
2	Westerwold tetraploid	–	8	81
		I	8	75
		II	8	80
		III	11	87
3	Italian tetraploid	–	15	84
		I	18	77
		II	19	77
		III	13	84

It was observed in this experiment that none of the fractions were appreciably better than the original samples.

Seed treatment experiments

General considerations

When a blind seed infection is eradicated by seed treatment, the low germinating capacity of the seed caused by the disease will not be restored to a proper level. Still, the infection having been killed the low germinating capacity might be compensated by increasing the sowing density. Thus infected "elite" seed lots might be made fit for multiplication purposes.

In the seed treatment experiments the waterdrop method was used for selecting heavily infected samples, and the agar method for determining the surviving infection after treatment. The blind seed disease is caused by a slow-growing fungus, so that after plating the seeds on agar it is easily overgrown by saprophytic fungi from the interior of the seed. In untreated or insufficiently treated samples such fungi are prevalent and will prevent the blind seed fungus to appear from those seeds in which they occur. Consequently, the agar method is unfit for such "dirty" samples. In as much as the infection can only be detected in a small number of otherwise "clean" seeds, the statistical error of the determination will be a large one. Moreover, it might be so that the infected seeds, that have passed through a honeydew stage and of which the embryo has been killed, are more readily accessible to saprophytes resulting in a systematic error being added to the statistical error. So, whereas the waterdrop method is unfit for treated samples as it is not a viability test, the agar method was found to be unfit for non-treated samples as these usually harbour too many quick-growing fungal infections. For these reasons, when conducting seed treatment experiments in connection with blind seed disease of ryegrass, one has to use different

and incomparable methods before and after treatment and it is difficult to draw reliable conclusions. Therefore, the original infection percentages of the samples used for seed treatment experiments have not been mentioned in this publication; it may suffice to know that the samples used had an infection from 60 to 90% according to the waterdrop method (with severe judgment).

In the pertinent literature two methods of seed disinfection have been indicated. CALVERT & MUSKETT (1945) in Northern Ireland advocated a hot-water treatment with 30 minutes at 50°C; NOBLE & GRAY (1945) in Scotland combined heat with mercury when advising a treatment of 20 minutes at 50°C in a 0.25% solution of organic mercurial.

Own experiments

The author found none of the two above mentioned treatments quite satisfactory. In different experiments with the same method results may be widely diverging. However, for 18 heavily infected samples the average infection surviving the 30 minutes 50°C treatment amounted to 1.4%. In an earlier experiment with the method developed by the Scottish workers the remaining infection in two samples was only 0 and 0.2%, respectively; in a later experiment with five samples the average remainder was 9.4 and, when it was repeated, 4.9%. When the duration of this mercurial treatment at 50°C was increased to 30 minutes still traces of the infection survived (averages for five samples: 0.2% and, when repeated, 0%).

An important feature in every seed treatment experiment is also the effect of the treatment on the healthy seeds. For determining this it is preferable not to use heavily infected samples, as the killing of the fungus may cause a slight increase in germinating capacity. Therefore, disease-free samples were included in every experiment. In doing so, it was found that the 30 minutes 50°C treatment decreased the average germinating capacity of ten samples from 91.7 to 87.4%. The mercury-wet treatment with 20 minutes at 50°C decreased the average germinating capacity of two healthy samples in the first trial from average 90 to 80.5%. Apparently both treatments are not harmless for the seed.

Germinating capacity is not a good measure for evaluating seed weakness in every seed species. In ryegrass, however, it can be relied upon as such, for in a non-sterile soil test at 12°C a number of 30 samples from different seed treatment experiments showed an average emergence of 68% normal seedlings whereas their germinating capacity reached an average of 75%. The gap between germinating capacity (determined under optimal conditions of germinating) and emergence in natural soil (adverse conditions) is not very wide. Consequently, the former can be safely used for evaluating treated ryegrass seed.

A number of experiments were conducted using a 0.25% mercurial solution with different durations and temperatures of the treatment, but none of these dip treatments proved to be satisfactory from the viewpoint of disease control. Several of them caused an appreciable injury of healthy seeds.

Also a Panogen-type treatment, with dosages from 0.5 to 1.5%, still left 6% infection surviving in heavily infected seed samples after the highest dosage, whereas already the 0.75 dosage impaired the germinating capacity of a healthy sample.

Additional experiments were made in which the seeds were treated for 24 hours at 30°C with a 0.2% thiram suspension, as used by MAUDE (1963) against

seed-borne *Ascochyta* spp. in peas. In four heavily infected samples the average surviving infection amounted to 5.4% whereas germinating capacity was not impaired. Increasing the temperature to 35°C caused a severe reduction in germinating capacity by a 24 hours' treatment whereas still a trace of the infection survived. An increase of the concentration of the thiram suspension did not improve the results.

Several experiments were made with Ustilgan, the German product used against loose smut in cereal seeds. With a 24 hours' treatment at a temperature of 12°C and a dosage of 25 or 50 ml of the commercial product, respectively, per liter seed the average surviving infection in six heavily infected samples was 15.1 and 9.6% for the two dosages. But the higher concentration injured the seed, reducing the germinating capacity of four healthy samples from 90 to 80%.

Some experiments were also made with pimaricin and its formulation pimafucin, which in the past have been successfully applied against several deep-seated seed-borne infections (DEKKER, 1955, 1957; VAN DER SPEK, 1962). These substances, however, proved to be unsatisfactory for blind seed disease control. In the first experiment, with soaking of the seed in a 100 ppm pimaricin solution for 24 hours at 20°C, an infection percentage of 20% survived the treatment while the germinating capacity was hardly affected. In a second experiment, using 200 ppm pimafucin for 24 hours at temperatures of 10, 15, 20, 25 and 30°C, the average infection of two samples was reduced from 46% after the 10°C treatment to 11% after the 30°C treatment. Soaking for half an hour at 50°C in 100 ppm pimafucin left a 16% infection in two samples and germinating capacity for two others decreased from 88 to 80%.

Some experiments were made with the "water-soak treatment" studied by TYNER (1957) for the control of loose smut in barley and wheat. An amount of water one third of the seed weight was added to the seed. Sometimes disinfectant chemicals were dissolved in the water. The moistened seed was kept for 48 hours at 23°C in bottles that were wholly filled with seed and were airtight closed. The average surviving infection in two samples was 7.5% when tap water had been used, 12% with 0.2% thiram suspension, 15% with a 0.1% $HgCl_2$ solution, and 14.5% with a 100 ppm pimafucin solution. By and large all these alternative chemical and combined treatments appeared to be unsatisfactory.

The best result was obtained with the new German one-phase warm-water treatment against loose smut in cereals (FLENSBERG, 1950). In a first experiment with this method the infection of two samples was reduced to 0% in all cases by 2 and $2\frac{1}{2}$ hours at 45° or 46°C, respectively. Germinating capacity of two healthy samples was not impaired at all. Also when 0.25% mercurial solution was used instead of plain water, these combinations of temperature and duration resulted in zero percentages surviving whereas scarcely decreasing germinating capacitiy. In another experiment in which ten samples received a warm-water treatment for two hours at 45°C no infection survived in any of the samples. This method was actually the only one of the many methods tried by which also the internal seed-borne saprophytical fungi were largely eradicated, thereby increasing the reliability of the *Gloeotinia* figures obtained and increasing confidence in the method.

DISCUSSION

The blind disease in ryegrass seed is known to be deep-seated. For this reason its control may be presumed to be difficult. This was confirmed by the experimental results. Two methods recommended by earlier workers appeared to leave part of the infection surviving and a number of methods recommended for other deep-seated seed-borne infections were not satisfactory either.

However, since the presence of traces of seed-borne infection may cause an epiphytotic disease development in the crop grown from the infected seed, a 100% control is absolutely necessary. Moreover, many of the methods tried caused injury to the seed itself. If possible this should be avoided.

After many experiments with chemical treatments finally warm-water treatments of 2 and $2\frac{1}{2}$ hours at 45° or 46°C appeared to result in absolute control of the infection without injury to the seed itself. Even the lightest treatment, with tap water during two hours at 45°C, left no trace of originally heavy infections surviving. And even the most severe treatment, with 0.25% mercurial solution during $2\frac{1}{2}$ hours at 46°C, scarcely injured the seed itself.

In the Netherlands the disease is of old present but its development has seldom reached alarming proportions. Even in the 1965 crop season, when it did cause a problem, many samples of the heavily infested coastal districts had little or no infection and samples of the dryer South-eastern part of the country always had little or no infection. Apparently the country is a border region for this disease which, as previously mentioned, is always present but rarely prevalent. This makes any control measures somewhat arbitrary, for under normal weather conditions even the sowing of heavily infected seed will not have serious consequences.

The one-phase warm-water treatment is a simple one. Many seed firms that handle cereal seeds possess the necessary equipment and experience for its application. The careful redrying of the treated seed lots should not really cause them any difficulties. The total quantity of ryegrass seed to be used for further seed production in Holland amounts to a few thousand kilograms only, and in any case the method should be applicable to small quantities of very valuable seed. It remains to be seen whether it is more practical than the possibility of long storage with the fungus spontaneously dying-off. This latter method of control could not yet be checked by the author. It should, however, be realized that any storage conditions that are favourable to the seed, e.g. a low moisture content and a low temperature, may also be expected to be congenial to the seed-borne infection. In other words, measures intended to improve survival of the seed may also facilitate survival of the fungus.

The application of any control methods in Holland will always be counteracted by the fact, that in most years the disease may not develop seriously owing to the weather conditions not being quite conducive to the fungus. On the other hand, in exceptionally rainy seasons even a slight seed-borne infection may have disastrous consequences.

SAMENVATTING

De blinde-zadenziekte van raaigras is van oudsher in Nederland aanwezig. In de meeste jaren is de schimmel in vele monsters aantoonbaar en in sommige jaren bereikt hij in enkele monsters hoge percentages. Tot dusver is dit geen re-

den tot verontrusting geweest. Gedurende het zeer regenrijke seizoen van 1965 ontwikkelde de ziekte zich echter sterk in de genaalde raaigrassen, terwijl Engels raaigras, dat blijkens de eigen ervaring en de buitenlandse literatuur wel degelijk vatbaar is, slechts zelden sterk geïnfecteerd raakte.

Met de druppelmethode werd voor een representatieve reeks van ruim 200 monsters Italiaans en Westerwolds raaigras een gemiddelde infectie gevonden van 19,2%. Het Westerwolds raaigras bleek zwaarder besmet dan het Italiaans en voor beide werd in de tetraploïde monsters een hoger gemiddelde gevonden dan in de diploïde. Hierbij dient echter te worden vermeld, dat de beoordeling in deze methode streng is geweest. Een onderzoeker in Noord-Ierland, naar wie enkele monsters werden opgezonden, vond daarin percentages die ongeveer een derde lager waren dan door ons waren gevonden.

De ziekte bleek vooral op te treden in het Noorden en Westen van het land, hoewel ook uit die gebieden wel gezonde of vrijwel gezonde monsters werden ontvangen, en bereikte een laag gemiddelde in het Zuid-Oosten, waar echter minder raaigras wordt geteeld.

Ook in overjarige monsters werd de infectie aangetroffen, soms in hoge percentages. Vergelijking van de infectie in eerder gebruikt zaaizaad met die in de daaruit gewonnen partijen toonde aan, dat hij gemiddeld in 1965 tot ruim het viervoudige was toegenomen. Een geringe infectie in het uitgezaaide zaad kan aanleiding geven tot een zeer sterke infectie van het gevormde zaad.

De infectiegraad van de monsters bleek in sterke mate bepalend voor de kiemkracht. Voor het verband tussen beide werd ongeveer een 45°-lijn gevonden, terwijl de correlatiecoëfficiënt tussen de infectie- en de kiemkrachtspercentages 0,77 bedroeg.

Verbetering van zwaar geïnfecteerde partijen door scherpere schoning bleek niet mogelijk. Twee door buitenlandse onderzoekers aangegeven methoden ter bestrijding van de zaadinfectie waren onvoldoende, evenals een aantal nu tegen de infectie beproefde alternatieven.

Een warm-waterbehandeling van 2 of 2½ uur bij 45° of 46 °C daarentegen bleek afdoende zonder noemenswaardige schade toe te brengen aan het zaad. Deze methode, die in Duitsland is ontwikkeld ter bestrijding van stuifbrand in granen, is vrij eenvoudig toe te passen. Vele firma's zijn in het bezit van de daarvoor benodigde apparatuur en ervaring. Voorzichtig drogen van het zaad na de behandeling is natuurlijk vereist; dan zullen de kiemkracht en de opkomst in grond er nauwelijks door worden verlaagd.

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