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Effect of storage duration and temperature on the survival of Rhizoctonia solani in tulip and iris bulbs

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Abstract

In general, the viability of *Rhizoctonia solani* in lesions of stored tulip and iris bulbs decreased rapidly after harvest. However, some of the mycelium remained viable and acted as source of infection after planting. Temperature had no influence on the rate of survival, as estimated by isolation on an agar medium, but after planting more *Rhizoctonia* grew out on iris bulbs which had been stored continuously at 30 °C for 20 or 32 weeks than on bulbs kept at lower temperatures. The surviving fungus was also able to infect neighbouring iris plants. The presence of healthy iris bulbs close to similar but diseased bulbs promoted the development of *Rhizoctonia* on the latter after planting.

Introduction

Besides infection of ornamental bulbs by *Rhizoctonia solani* Kühn from infested soil, it seems possible that affected bulbs among the planting stock transmit the disease to the next crop. Little is known about the survival rate of the pathogen in such bulbs

Fig. 1. Symptoms of *Rhizoctonia solani* on tulips bulbs; A) on the tunic before it has turned dark brown; B) slightly depressed yellowish lesions on the scale; C) severe infection of the scale, which has cracked and partly disappeared.

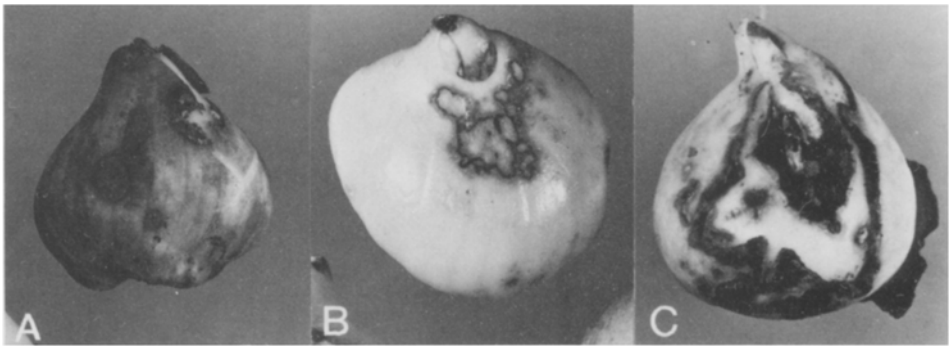

Fig. 1. Symptomen van Rhizoctonia solani op tulpebollen; A) op de huid voordat deze donkerbruin is geworden; B) enigszins ingezonken, gelige lesies op de rok; C) zware infectie van de rok, die daardoor is gescheurd en gedeeltelijk verdwenen.

during storage under the temperature regimes necessary for optimal growth or for flowering at desired times.

Symptoms on diseased iris bulbs remain manifest throughout long storage periods (Doornik, 1975), but the sorting out of diseased bulbs is time-consuming and incomplete. Symptoms on tulip tunics (irregularly shaped light-brown spots, Fig. 1A) can only be recognized with certainty if the bulbs have been lifted before the tunics have turned brown completely, and only remain discernible for a few months after harvest. Symptoms on the underlying scale tissue (irregularly shaped, slightly depressed yellowish spots with a dark rim, Fig. 1B) can only be found by peeling off the brown tunic. If infection is severe, the tunics have cracked before harvest and the greater part of the infected tissue will be lost, sometimes leaving parts with irregular blackish rims. The outer scale may show dark-brown patches where the scale tissue may have been ruptured before harvest (Fig. 1C).

Since all diseased bulbs cannot be removed and disinfection of planting stocks was not always satisfactory, some information was collected on the survival of the pathogen in tulip and iris bulbs.

Material and methods

Tulip and iris bulbs showing symptoms of infection with *R. solani* were selected either for isolation of the pathogen from lesions during storage or for planting after the appropriate storage treatments.

Isolation from lesions was done by plating on water agar to which inulin and a selective solution containing benomyl, aureomycin, and copper sulfate had been added (Doornik, 1981b).

Bulbs were planted separately in pots unless otherwise stated, and grown under controlled conditions suitable for the isolate under study (warmth-preferring isolate; Doornik, 1981a). Survival was determined according to formation of fresh symptoms on bulbs and/or sprouts. In some experiments radish seedlings or a healthy iris bulb was grown in the pot together with the diseased bulb. Among the numerous temperature treatments applied to both crops for various purposes, great attention was paid to the temperatures used most frequently, i.e., 20 and 5 °C for tulips and 30, 17, and 9 °C for induction of flowering in iris.

Results

Survival in tulip. The frequency of isolation of the pathogen from tunic lesions during storage at 20 °C decreased rapidly from 83% at lifting in June to 32% and 10% in July and August, respectively. Isolations on the same dates from lesions on the underlying scales of the same bulbs yielded the fungus in 69%, 14%, and 3% of the three sets of platings, respectively. Storage of similar bulbs at 7 temperatures ranging between 5 °C and 35 °C for 14 weeks showed no influence of temperature on the percentages of isolation. Table 1 gives the results of isolations from scales of bulbs which had been stored constantly at the two temperatures used most commonly for tulips, viz., 5 and 20 °C. After storage for more than 14 weeks viability was virtually absent.

An attempt was also made to assess the viability of the pathogen in scale lesions by planting diseased bulbs after prolonged storage (18 weeks) at 20 °C throughout or 6

Table 1. Influence of temperature and duration of storage on percentages of lesions on scales of tulip bulbs from which *R. solani* was isolated.

Storage temperature (°C)	At date of harvest	Duration of storage (weeks)		
		1	5	14
5	64	43[1]	16	5
20		43	12	2

[1] Isolations from 50-100 lesions each.

Tabel 1. Invloed van temperatuur en duur van bewaring op percentages lesies op tulperokken waaruit R. solani kon worden geïsoleerd.

weeks at 20 + 12 weeks at 5 °C. The tunics were removed before planting, because at that time tunic symptoms could not be recognized with certainty. Thus, the bulbs were selected solely on the basis of lesions on the scale. Because after planting, symptoms of *Rhizoctonia* infection on the bulb surface are often masked by a secondary attack by *Penicillium* spp., the viability of the fungus in scale lesions could only be estimated on the basis of the appearance of symptoms on the outgrowing sprouts.

When bulbs of six cultivars (50 or more bulbs per cultivar) with symptoms on the outer scales were grown separately in pots, only a few sprouts became infected (0-6%), and in subsequent years the percentages were even lower. No increase in the frequency of sprout infection was obtained by changing the soil temperature after planting or by influencing the growth rate of the sprouts via pre-planting storage conditions. The presence of radish seedlings *(Raphanus sativus)*grown around the tulip in the pots did not influence the rate of sprout infection. This differs from the findings made by Kamal and Weinhold (1967) in studies on *Rhizoctonia* in cotton.

Survival in iris. In irises the symptoms of infection of the husks remain conspicuous, and therefore attempts to isolate the fungus from husk lesions could be continued for almost eight months. Isolation from the lesions on husks was possible much longer than isolation from scale lesions (Table 2). However, as in tulips, the percentages of *Rhizoctonia* isolations decreased considerably with increasing duration of the storage period. There was no obvious influence of storage temperatures between 2 °C and 30 °C on the isolation percentages (Table 2).

For further investigation of the viability of the pathogen in the bulbs, irises with many *R. solani* lesions were selected after lifting. These bulbs were stored for various periods at 30 °C (a temperature often used for retardation of flowering), followed by 17 °C (necessary for root and shoot outgrowth after warm storage), and were then planted singly in pots and held at 17 °C. Six weeks later, they were lifted and the occurrence of new symptoms on both bulbs and sprout was evaluated. This is possible in iris bulbs because the original symptoms caused by *R. solani* persist recognizably after planting. Here, too, development of new symptoms decreased with increasing storage duration (Table 3). Bulbs were also stored continuously at 2, 9, 17, or 30 °C for 20 or 32 weeks before being planted separately in pots at 17 °C. A decrease in symptom development on bulbs and sprouts was seen 6 weeks after planting of bulbs

Table 2. Influence of temperature and duration of storage on percentages of lesions on husks and scales of iris bulbs from which *R. solani* was isolated.

Storage temperature (°C)	Lesions on husks						Lesions on scales			
	storage duration (weeks)									
	at date of harvest	3½	12	18	21	34	at date of harvest	3½	12	18
2	86	53[1]	31	38	23	7	69	16	52	0
9		75	79	33	22	10		32	53	0
17		88	59	29	22	12		60	17	0
30		75	75	13	8	13		41	43	3

[1] Isolations from 50 lesions each.

Tabel 2. Invloed van temperatuur en duur van bewaring op percentages lesies op huiden en rokken van irissen waaruit R. solani kon worden geïsoleerd.

Table 3. Influence of duration of storage on percentages irises showing symptoms on bulb and sprout 6 weeks after planting at 17 °C.

Storage at 30 °C (weeks)	Subsequent storage at 17 °C (weeks)	% plants[1] showing disease development
2	8	10
7	8	7
20	6	3

[1] 50-100 plants per treatment.

Tabel 3. Invloed van de lengte van de bewaarperiode op het percentage irissen dat 6 weken na het opplanten van de bollen nieuwe symptomen op bol en/of spruit vertoonde.

which had been stored for a longer time (Table 4). On both planting dates, however, bulbs stored at 30 °C showed more disease development than did those exposed to lower storage temperatures.

Instead of the use of radish seedlings to stimulate the fungus present in lesions after planting, a healthy bulb was planted adjacent to a diseased one in the same pot. In this experiment, which was carried out simultaneously with the preceding one, some of the bulbs stored at 9 or 30 °C for 20 or 32 weeks were used. Symptoms on the diseased bulbs and their outgrowing sprout developed much more frequently than on the infected bulbs of the same lots grown singly in pots (Table 4). This indicates that the presence of the healthy iris plant nearby had stimulated the activity of the pathogen in the infected ones. This stimulation was so strong that some of the healthy neighbouring iris plants were also affected: of the healthy material that had been stored at 9

Table 4. Influence of storage temperature, duration of storage, and adjacence of healthy bulbs, expressed as percentages of irises showing development of symptoms on bulb and sprout 7 weeks after planting at 17 °C.

Duration of storage (weeks)	Not paired with healthy bulb (storage temperature (°C))				Paired with healthy bulb (storage temperature (°C))	
	2	9	17	30	9	30
20	3[1]	31	24	51	40	58
32	0	0	4	33	31	41

[1] 50-100 plants per treatment.

Tabel 4. Invloed van de temperatuur, duur van de bewaring en de aanwezigheid van een gezonde bol op de percentages irissen met ontwikkeling van symptomen op de bol en de spruit 7 weken na het planten bij 17 °C.

or 30 °C for 20 weeks, 36 and 33% showed symptoms 6 weeks after planting, respectively, and for the bulbs stored for 32 weeks these percentages were 29 and 23.

In similar experiments performed under the same conditions in other years, the presence of healthy bulbs had a similar though less pronounced effect. Once again, a relatively small number of healthy neighbouring plants became infected when the fungus in the diseased bulb was viable.

Discussion

In commercial forcing to produce tulip flowers, particularly early in the winter, damage inflicted by *R. solani* is sometimes attributed to bulb-borne inoculum. This holds especially when considerable infection is found within more or less clearly defined patches of disinfected glasshouse soil. The results of the present experiments with tulips do not support the view that transmission by dormant infections plays an important role in tulips. Re-isolation of the fungus from tulip tunics was not possible after some months of storage, because at that time symptoms could not be recognized with sufficient certainty, but it is conceivable that the fungus remains viable longer in the tunic than in the scale tissue and can thus contribute appreciably to the importance of planting-stock infection, in analogy with the situation in iris husks and scales (Table 2). In the present experiments, the pre-planting removal may have had an adverse effect on the rate of symptom development after planting while the impossibility to judge the development of new symptoms on the scales because of *Penicillium* growth may also have played a role. Because of the extremely low rate of isolation from scale lesions after 14 weeks of storage (when the bulbs are about to be replanted), the survival of dormant pathogen in the tunic was not further investigated.

Percentages of successful re-isolation from both kinds of bulbs were not influenced conspicuously by storage temperatures (Tables 1 and 2), but planted iris bulbs showed distinctly more development of *R. solani* symptoms after storage at 30 °C than at lower temperatures (Table 4) and much more than could be expected from the isolation data (Table 2).

Why such a relatively high temperature (and low humidity) promotes survival of the pathogen is not known. Apparently, re-activation of the fungus in the lesions occurs more easily under normal conditions in soil than on the nutrient-poor selective medium. Moreover, percentages of successful isolation were based on platings of single lesions, whereas bulbs for planting were selected for the presence of at least 4 lesions.

Breaking of dormancy of some kind was accelerated in irises by the presence of a healtly plant in the same pot (Table 4), which suggests that exudates produced by healthy bulbs play a role. In tulips the rates of symptom development after planting were so low and erratic that an effect of the presence of other host plants, e.g. radish seedlings, was not apparent.

Samenvatting

Het effect van de duur van de bewaring en de temperatuur op de overleving van Rhizoctonia solani in tulpe- en irisbollen

De levensvatbaarheid van *Rhizoctonia solani* in lesies op tulpe- en irisbollen nam tijdens de bewaring na de oogst in het algemeen snel af. Er bleef echter enig mycelium in leven, dat na het planten als infectiebron fungeerde. De temperatuur had geen invloed op de mate van overleving wanneer de mate van slaging van isolaties op een agarmedium als criterium werd genomen. Na planten groeide echter meer *Rhizoctonia* uit op irisbollen die permanent gedurende 20 en 32 weken bij 30 °C waren bewaard dan bij bollen die bij lagere temperaturen waren opgeslagen. De overlevende schimmel was ook in staat om naburige irissen aan te tasten. De aanwezigheid van gezonde irissen in de nabijheid van aangetaste bevorderde de ontwikkeling van *Rhizoctonia* op geplante zieke bollen.

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