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Reactions of potato varieties to skin spot (*Oospora pustulans*) infection and transmission in different soils[1]

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Zusammenfassung, Résumé p. 315

Summary

Emergence delay and blanking caused by skin spot were shown to depend on the degree of seed infection and were intensified by heavier soil. From similarly affected seed they were significantly less with *Kerr's Pink* than with *King Edward, Majestic* or *Redskin.*

Growth was very similar from normal and necrotic buds of *Kerr's Pink* but virtually no growth was recorded from necrotic *King Edward* buds, suggesting that sprout vigour influences field response to skin spot.

Transmission of infection in *King Edward* to stem bases, stolons and progeny tubers depended on seed infection and even minimal inoculum caused stolon and tuber infection especially in heavier soils. With severely infected seed transmission was greatly reduced in light soil. This indicates one means of reduction of disease incidence.

Colonisation by *Oospora pustulans* of stem bases and stolons probably provides inoculum multiplication centres. Maximum colonisation was detected generally in September and declined during senescence.

Introduction

Potato varieties vary in susceptibility to skin spot (*Oospora pustulans*) from highly resistant such as *Dunbar Rover* and *Golden Wonder* to very susceptible such as *Kerr's Pink* and *King Edward* (Boyd, 1957; Boyd and Lennard, 1961; Nagdy and Boyd, 1965). Nagdy and Boyd (1965) also showed that when tubers of different varieties were artificially inoculated with *O. pustulans*, their relative susceptibility to surface and eye infection was similar. With some varieties, however, susceptibility to skin spot appears to bear little relationship to the effect of the disease on crop growth. *King Edward* is known to sustain delays in emergence and blanking in crops grown from seed infected with skin spot, while an equally susceptible variety such as *Kerr's Pink* is not similarly affected. Thus there appear to be other factors involved in overcoming the damaging effects of this disease.

The effects of skin spot infection of seed tubers on crop growth and disease transmission to the resulting crop have been examined with *King Edward* (Boyd and Len-

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nard, 1961). One of the purposes of this investigation was to compare other varieties in the same way on different types of soil. There is evidence that soil type can affect skin spot infection (Khrobrykh, 1959; Gomolyako, 1959; Salt, 1964), but no evidence of its effect upon the growth from infected seed or upon transmission of infection to the subsequent crop has been published.

Materials and methods

After preliminary experiments with *King Edward* and *Kerr's Pink*, in 1966 seed tubers of a number of potato varieties with varying levels of skin spot were planted at the same time in 4 replicate randomised field plots, twelve tubers per plot in soils of two different types. The seed infection was assessed visually and ranged from 'free' or trace surface infection with no eyes infected to moderate or severe surface infection with all eyes infected.

In 1968–1969 further experiments were carried out on three different soils. Using only *King Edward*, seed of three infection groups was planted in five randomised blocks with one blank row between each plot. In this case the 'free' seed showed no obvious infection and was taken from 4th-year produce of stem cuttings originally free from skin spot (Hirst and Hide, 1967). The soils used were classified as sand, loamy sand and sandy clay-loam; their mechanical analyses and the number of years since the last potato crop are shown in Table 1. In 1964 also examination was made of sprout growth from necrotic and normal eyes of *King Edward* and *Kerr's Pink* tubers, both inoculated with *O. pustulans* and uninoculated.

After planting, emergence counts were taken at weekly intervals on all plots, and

Table 1. Mechanical analysis and other data of soils used

Date[1]	Texture scale[2]	Coarse and fine sand[3] % (0.02-2 mm)	Silt[4] % (0.002-0.02 mm)	Clay[5] % (< 0.002 mm)	Stones[6] % (> 2 mm)	Years after potato crop[7]
1966	1 sand[8]	89.7	2.8	4.0	–	20
	2 sandy clay-loam[9]	59.1	16.0	19.3	–	6
1968	1 loamy sand[10]	87.0	3.2	9.8	15.9	4
	2 sandy clay-loam[9]	65.0	14.0	21.0	36.8	9
	3 sandy clay-loam[9]	69.0	10.0	21.0	5.8	8

[1] *Datum – Date*
[2] *Bodenart – Texture*
[3] *Grober und feiner Sand – Sable grossier et fin*
[4] *Schluff – Alluvion*
[5] *Tonboden – Argile*
[6] *Steine – Pierres*
[7] *Jahre nach Kartoffelbau – Nombre d'années après une culture de pommes de terre*
[8] *Sand – Sable;*
[9] *Schwach toniger Lehm – Limon sablo-argileux*
[10] *Lehmiger Sand – Limono-sablonneux*

Tabelle 1. Körnungsanalyse und andere Angaben über die gebrauchten Böden.
Tableau 1. Résultats d'analyse mécanique et diverses données sur les sols expérimentés.

from them the number of days taken for the average plant to emergence, i.e. the emergence rate, was calculated (Boyd and Lennard, 1961). Finally, the number of plants in each plot was also recorded.

Plots were harvested usually in the second week of October, and the tubers stored in net bags in one clamp until the following March when skin spot development was assessed and expressed as indices of surface infection (Boyd, 1957) and eye infection (Nagdy and Boyd, 1965). The surface infection index (SII) is based on severe, moderate, slight and trace surface infection and represents the percentage of the surface covered. The eye infection index (EII) represents the percentage of eyes affected. The severely infected seed would merit the figures of 67.5 for SII and 100 for EII, those for the 'free' or trace seed being 1.0 and 0, respectively.

Results

Emergence and blanking in different varieties

The rates of emergence and percentage blanking in 1966 after planting *King Edward*, *Kerr's Pink*, *Majestic* and *Redskin* with two levels of seed infection in two types of soil are shown in Tables 2 and 3. Emergence was significantly slower in the sandy clay-loam than in the sand and also where seed infection was higher. Comparison of emergence differences caused by infection between the four varieties shows that *Kerr's*

Table 2. Emergence from seed tubers of four varieties with different levels of skin spot infection planted on types of soil, 1966.

Soil type[1]	Seed infection[2]	*King Edward*		*Majestic*		*Redskin*		*Kerr's Pink*	
		emergence (days)[3]	blanking[4] (%)	emergence (days)[3]	blanking[4] (%)	emergence (days)[3]	blanking[4] (%)	emergence (days)[3]	blanki (%)
1 sand[5]	severe, all eyes[6]	47.7	35.0	49.8	21.0	48.7	16.0	37.9	0
	free/trace, no eyes[7]	35.8	2.1	37.1	0	39.6	0	35.3	2.1
2 sandy clay-loam[8]	severe, all eyes[6]	66.2	31.0	69.7	43.0	64.7	21.0	55.4	2.1
	free/trace, no eyes[7]	50.0	0	66.8	8.3	57.4	2.1	50.0	0

[1] *Bodenart – Type de sol*
[2] *Pflanzgutinfektion – Degré d'infection*
[3] *Auflaufen (Tage) – Levée (jours)*
[4] *Lückigkeit – Non-levée*
[5] *Sand – Sablonneux*
[6] *Stark, alle Augen infektiert – Sévère, tous les yeux infectés*
[7] *Frei/Spuren, Augen nicht infektiert – Absence ou trace, aucun oeil at.*
[8] *Schwach toniger Lehm – Sablo-argilo-limoneux*

Tabelle 2. Auflaufen von Pflanzknollen von vier Sorten mit verschieden starker Infektion mit Tüpfel-fleckigke zwei Bodenarten, 1966.

Tableau 2. Levée de plants de quatre variétés atteints d'oosporiose à differents degrés plantés dans deux types de en 1966.

Table 3. Influence of various factors on mean emergence and blanking, 1966.

Variety[1]	Emergence[2]	Blanking[3]
King Edward	50.0	17.0
Majestic	52.2	18.0
Redskin	51.2	10.0
Kerr's Pink	44.7	1.0
LSD $P < 0.01$	3.1	11.5
$P < 0.001$	4.1	15.1
Soil type[4]	Emergence[2]	Blanking[3]
Sand[5]	40.7	9.5
Sandy clay-loam[6]	58.2	13.4
LSD $P < 0.01$	2.2	8.2
$P < 0.001$	2.9	10.1
Seed infection[7]	Emergence[2]	Blanking[3]
Severe, all eyes[8]	52.0	19.0
Free/trace, no eyes[9]	45.0	2.0
LSD $P < 0.01$	2.2	8.2
$P < 0.001$	2.9	10.1

[1] *Sorte – Variété*
[2] *Auflaufen – Levée*
[3] *Lückigkeit – Non-levée*
[4] *Bodenart – Type de sol*
[5] *Sand – Sable*
[6] *Schwach toniger Lehm – Sablo-argilo-limoneux*
[7] *Pflanzgutinfektion – Degré d'infection*
[8] *Stark, alle Augen infektiert – Sévère, tous les yeux atteints*
[9] *Frei/Spuren, Augen nicht infectiert – Absence ou trace, aucun oeil atteint*

Tabelle 3. Einfluss verschiedener Faktoren auf Auflaufen und Lückigkeit (Mittelwerte, 1966).
Tableau 3. Influence de divers facteurs sur les moyennes de levée et de non-levée, 1966.

Pink was significantly least affected, the average delay in both soils being 14 and 4 days for *King Edward* and *Kerr's Pink*, respectively.

The blanking generally followed the same pattern as emergence although *Majestic* as well as *King Edward* appears to have reacted seriously to infection. However, the high degree of blanking in *Majestic* plots in the sandy clay-loam, even after planting seed with trace infection, must have been caused by other factors such as dry rot (*Fusarium* spp.). *Kerr's Pink* on the other hand showed a virtual absence of blanking due to skin spot in either soil. It is interesting also that even with severely affected *King Edward* seed with infection at all eyes, two out of three such tubers produced a plant. Furthermore, although the heavier soil increased the delay in emergence, there was no corresponding general increase of blanking probably due to the comparatively low incidence with *King Edward* in the heavier soil.

Bud necrosis

Small samples of *King Edward* and *Kerr's Pink* tubers were examined soon after lifting in October 1964 and the condition of the bud tissues of the eyes recorded. Sub-samples

Table 4. Sprout growth from necrotic and non-necrotic buds of *King Edward* and *Kerr's Pink* tubers.

Variety[1]	Initial bud necrosis (%), October[2]	Bud necrosis (%), May[3]		Growth from necrotic and non-necrotic buds (%), July[4]	
King Edward	39	not inoculated[5]	89	necrotic[7]	0
				non-necrotic[8]	60
		inoculated[6]	96	necrotic[7]	4
				non-necrotic[8]	50
Kerr's Pink	25	not inoculated[5]	32	necrotic[7]	55
				non-necrotic[8]	61
		inoculated[6]	79	necrotic[7]	29
				non-necrotic[8]	33

[1] *Sorte – Variété*
[2] *Ursprüngliche Knospennekrose (%), Oktober – Nécrose du bourgeon initial en octobre (%)*
[3] *Knospennekrose (%), Mai – Nécrose des bourgeons en mai (%)*
[4] *Wachstum aus nekrotischen und nicht nekrotischen Knospen (%), Juli – Développement de pousses en % à partir de bourgeons nécrotiques et non-nécrotiques en juillet*
[5] *Nicht inokuliert – Non inoculé*
[6] *Inokuliert – Inoculé;*
[7] *Nekrotisch – Nécrotiques;*
[8] *Nicht nekrotisch – Non-nécrotiques*

Tabelle 4. Keimwachstum aus nekrotischen und nicht nekrotischen Knospen von Knollen der Sorte *King Edward* und *Kerr's Pink*.
Tableau 4. Développement de pousses à partir de bourgeons nécrotiques et non-nécrotiques de tubercules de *King Edward* et *Kerr's Pink*.

of each variety were inoculated by immersion in a spore suspension (10^6 spores per ml) for 1 min after preliminary washing and surface sterilisation. Control tubers were immersed in sterile water. All tubers were then stored at 5 °C and 90% RH until May when the eyes were examined. They were then transferred to open trays at 13 °C and sprout growth from necrotic and non-necrotic buds assessed in July.

Table 4 shows that in May natural infection was fairly extensive in the King Edward buds but less so with Kerr's Pink, the bud necrosis being clearly associated with visible skin spot symptoms. By no means all the non-necrotic buds produced growth in either variety in July; but whereas hardly any active sprout growth arose from the necrotic *King Edward* buds, with *Kerr's Pink* this figure was only about 5% fewer than that of the non-necrotic buds.

Effects of soils of three types

The rates of emergence and percentage blanking for *King Edward* planted in 1968 in soils of three types are shown in Table 5. With each soil the depressing influence of increasing seed infection upon growth is clearly seen. Even slight surface infection (i.e. less than 10% of the surface showing symptoms), with only some eyes infected, delayed the growth although showing no reduction of final emergence. Emergence was

Table 5. Skin spot: emergence rate and blanking of *King Edward:* seed with different infection levels planted in soils of three types, 1968.

Seed infection[1]	1 Loamy sand[2]		2 Sandy clay-loam[3]		3 Sandy clay-loam[3]	
	emergence (days)[4]	blanking[5] (%)	emergence (days)[4]	blanking[5] (%)	emergence (days)[4]	blanking[5] (%)
Free[6]	37.9	2	47.5	2	50.7	3
Slight, some eyes[7]	42.4	3	54.0	0	53.5	2
Mod./severe, all eyes[8]	48.7	24	66.4	33	65.1	44

[1] *Pflanzgutbefall – Degré d'infection*
[2] *Lehmiger Sand – Limon sablonneux*
[3] *Schwach toniger Lehm – Sablo-argilo-sablonneux*
[4] *Auflaufen (Tage) – Levée (jours)*
[5] *Lückigkeit – Non-levée*
[6] *Frei – Absence*
[7] *Einige Augen leicht – Légère sur quelques yeux*
[8] *Alle Augen mittel/stark – Modéré/sévère sur tous les yeux*

Tabelle 5. Tüpfelfleckigkeit: Auflaufrate und Lückigkeit *King Edward.* Verschiedene Grade von Pflanzgutinfektion in drei Bodenarten, 1968.
Tableau 5. Oosporiose: vitesse de levée et non-levée; plants *King Edward* de divers degrés d'infection plantés dans trois types de sol, 1968.

considerably delayed in the two heavier soils each of which had a similar effect. Blanking was negligible except where the heaviest seed infection had been used and here it was greatest in the second of the sandy clay-loams. It was surprising to find blanks occurring after planting the skin spot free seed. This will be discussed later.

Transmission to progeny

The produce of the plots in 1966 and 1968 was stored over winter and assessed for skin spot in spring.

Tables 6 and 7 show the effects of various factors influencing transmission of infection in 1966. Table 8 gives similar data for three soils in 1968. In Tables 6 and 7, transmission of surface infection was not influenced by variety but eye infection of the produce was significantly greater in *King Edward* and *Kerr's Pink* than in the other two varieties which are accepted as being less susceptible.

It is clear again that infection of the seed tuber is one of the chief factors which significantly governs infection of the produce, but it is surprising that the overall increase given by severe seed infection compared with 'free' or trace infection is only two-fold (Table 7) in both surface and eye and it would seem that even the highest index of eye infection of 46.5 in the produce of *Kerr's Pink* in the sandy clay-loam is considerably less than the theoretical 100 of the seed planted. In the same way with the visibly 'free' or trace category seed, the theoretical SII and EII figures of 1 and 0, respectively, was unexpectedly increased, for example, again with *Kerr's Pink*, to 7.7 and 28.1. In these cases, of course, assessments were made visually and thus no account was taken of the presence of the fungus which might have been detected microscopically on the skin or on buds without obvious symptoms.

Table 6. Skin spot infection of produce of four varieties of seed tubers with different infection levels planted in two types of soil, 1966.

Soil type[1]	Seed infection[2]	*King Edward*		*Majestic*		*Redskin*		*Kerr's Pink*	
		SII	EII	SII	EII	SII	EII	SII	EII
1 Sand[3]	severe, all eyes[4]	4.6	24.2	1.9	5.9	4.2	15.6	3.0	11.6
	free/trace, no eyes[5]	1.7	5.2	2.2	6.0	0.8	1.2	1.7	4.2
2 Sandy clay-loam[6]	severe, all eyes[4]	8.6	40.0	10.7	34.1	13.4	43.3	11.1	46.5
	free/trace, no eyes[5]	4.7	22.5	6.0	25.2	4.7	13.9	7.7	28.1

SII = Surface infection index – *Oberflächeinfektionindex – Indice d'infection de la surface*
EII = Eye infection index – *Augeninfektionindex – Indice d'infection des yeux*
[1] *Bodenart – Types de sol*
[2] *Pflanzgutbefall – Infection des plants*
[3] *Sand – Sablonneux*
[4] *Stark, alle Augen infektiert – Sévère tous les yeux infectés*
[5] *Frei/Spuren, Augen nicht infektiert – Absence ou trace, aucun oeil atteint*
[6] *Schwach toniger Lehm – Sablo-argilo-limoneux*

Tabelle 6. Befall mit Tüpfelfleckigkeit auf den Tochterknollen von vier Sorten. Verwendetes Pflanzgut mit verschiedener Befallsstärke, ausgepflanzt in zwei verschiedene Bodenarten, 1966.
Tableau 6. Infection d'oosporiose de la production, chez quatre variétés, de plants montrant divers degrés d'infection et plantés dans deux types de sols en 1966.

The effect of soil is shown in Table 7 also, the heavier soil in this case increasing infection on both skin and eyes by 3–4 times.

These results were supported by those of the 1968 experiments where three levels of seed infection and three soils were used (Table 8). The two higher levels of seed infection did not show much difference in transmission and there were not sufficient progeny tubers from the severely affected seed planted in the second sandy clay-loam plots to provide an adequate sample for assessment.

Before planting in this experiment the 'free' seed from stem cutting material had been examined by the eye core method (Hide et al., 1969) and incubation of 100 eyes had shown no sign of the presence of *O. pustulans*. However, in late July the original stock, which had been kept at about 5°C, was re-sampled and *O. pustulans* was observed on 3 % of the eyes.

It is not necessary therefore to postulate soil contamination and, in any case, the loamy sand and two sandy clay-loam soils had not carried a potato crop for 4, 9 and 8 years, respectively. If one assumes that most if not all infection in the progeny of the 'free' seed was transmitted by the minimal degree of infection on the seed, the build-up on the subsequent crop, particularly in the heavier soils, was considerable. Therefore although there is a broad relationship between infection on the seed and that on the progeny this may be modified by other factors such as soil conditions.

From Table 8 it is clear that although soils 2 and 3 are both classified as sandy clay-

Table 7. Influence of various factors on transmission of infection, 1966.

Variety[1]	SII	EII
King Edward	4.9	23.0
Majestic	5.2	17.8
Redskin	5.8	18.5
Kerr's Pink	5.9	22.6
LSD $P < 0.01$	2.3	3.1
$P < 0.001$	3.0	4.1
Soil type[2]	SII	EII
Sand[3]	2.5	9.4
Sandy clay-loam[4]	8.4	31.6
LSD $P < 0.01$	1.6	2.2
$P < 0.001$	2.2	2.9
Seed infection[5]	SII	EII
Severe, all eyes[6]	7.2	27.7
Free/trace, no eyes[7]	3.7	13.5
LSD $P < 0.01$	1.6	2.2
$P < 0.001$	2.2	2.9

SII = Surface infection index – *Oberflächeinfektionindex – Indice d'infection de la surface*
EII = Eye infection index – *Augeninfektionindex – Indice d'infection d'yeux*
[1] *Sorte – variété*
[2] *Bodenart – Type de sol*
[3] *Sand – Sablonneux*
[4] *Schwach toniger Lehm – Sablo-argoli-limoneux*
[5] *Pflanzgutbefall – Infection des plants*
[6] *Stark, alle Augen infektiert – Sévère, tous les yeux atteints*
[7] *Frei/Spuren, keine Augen infektiert – Absence ou trace, aucun oeil atteint*

Tabelle 7. Einfluss verschiedener Faktoren auf die Uebertragung der Infektion, 1966.
Tableau 7. Influence de divers facteurs sur la transmission de l'infection, 1966.

loam in texture there is a considerable difference in transmission. A further analysis of these soils was carried out on the gross sample to determine the proportion of stones greater than 2 mm, and Table 1 shows a considerable difference in this respect. Soil 2, having 36.8%, was thus much more freely drained than soil 3 which had 5.8%. Soil 2 would thus tend to be drier than soil 3 in the potato root zone and so, according to the suggestion that high rainfall during the lifting period is important (Boyd and Lennard, 1961), would be less likely to encourage skin spot transmission.

Progress of transmission

The same experiment was used to trace the progress of transmission. At 4 monthly intervals during the growing season, 2 plants per treatment were harvested and the underground portion of one of the main stems of each plant was selected and washed. Three stolons at different levels, i.e. top, middle and bottom of the stem, as well as the

Table 8. Skin spot infection on produce of *King Edward* seed with different infection levels planted in soils of three types, 1968.

Seed infection[1]	1 Loamy sand[2]		2 Sandy clay-loam[3]		3 Sandy clay-loam	
	SII	EII	SII	EII	SII	EII
Free[4]	0.2	1.2	0.9	8.5	3.9	35.4
Slight, some eyes[5]	2.1	15.4	6.6	54.2	7.6	62.5
Mod/severe, all eyes[6]	2.3	20.0	6.3	50.0	–	–

SII = Surface infection index – *Oberflächeinfektionindex – Indice d'infection de la surface*
EII = Eye infection index – *Augeninfektionindex – Indice d'infection des yeux*
[1] *Pflanzgutbefall – Degré d'infection*
[2] *Lehmiger Sand – Limon-sablonneux*
[3] *Schwach toniger Lehm – Sablo-argilo-sablonneux*
[4] *Frei – Absence*
[5] *Leicht, einige Augen – Légère sur quelques yeux*
[6] *Mittel/stark, alle Augen infektiert – Modéré/sévère sur tous les yeux*

Tabelle 8. Befall mit Tüpfelfleckigkeit auf Tochterknollen der Sorte *King Edward*. Verwendetes Pflanzgut mit verschiedener Befallsstärke, ausgepflanzt in drei Bodenarten, 1968.
Tableau 8. Infection d'oosporiose de la production de King Edward à partir de plants montrant différents degrés d'infection, plantés dans trois types de sol, 1968.

stem itself were excised and assessed for the extent of superficial browning. For this purpose the stems and stolons were divided into three equal parts, incubated for 5 days at 15 °C and high RH and an assessment made of the percentage surface area colonised by *O. pustulans*, which was detected by its ready sporulation.

The first assessment was made on 15 July, six weeks after planting and is shown in

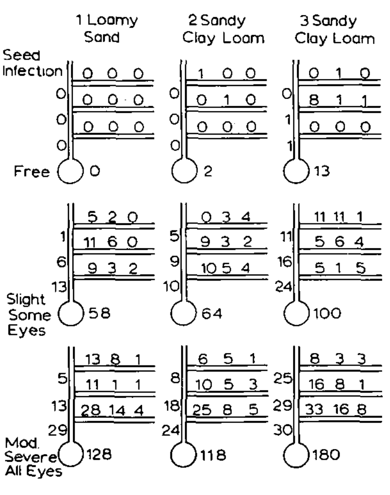

Fig. 1. Colonisation by *O. pustulans* of stem bases and stolons. Assessment (%) 15 July 1968

Loamy sand – *Lehmiger Sand – Limono-sablonneux*
Sandy clay-loam – *Schwach toniger Lehm – Sablo-argilo-limoneux*
Seed infection – *Pflanzgutbefall – Degré d'infection*
Free – *Frei – Absence*
Slight, some eyes – *Leicht, einige Augen – Légère, quelques yeux atteints*
Mod./severe, all eyes – *Mittel/stark, alle Augen – Modéré/sévère, tous les yeux atteints*

Abb. 1. Besiedlung durch O. pustulans an Stengelbasen und Stolonen. Beurteilung in %, 15. Juli 1968
Fig. 1. Colonisation par O. pustulans de la base des tiges et des stolons. Résultat en %, le 15 juillet 1968.

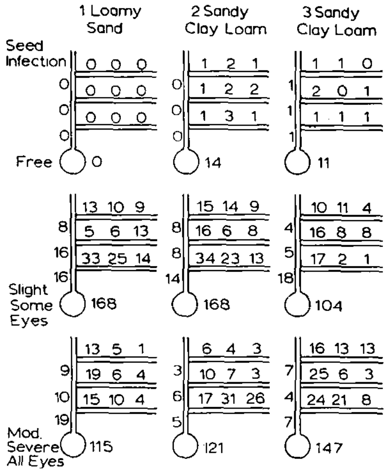

Fig. 2. Colonisation by O. pustulans of stem bases and stolons. Assessment (%) 9 Sept. 1968.

Abb. 2. Besiedlung durch O. pustulans an Stengelbasen und Stolonen. Beurteilung in %, 9. Sept. 1968. Siehe Abb. 1.
Fig. 2. Colonisation par O. pustulans de la base des tiges et des stolons. Résultat en %, le 9 Sept. 1968. Voir fig. 1.

Fig. 1. In each instance the figure at the base is an index of total colonisation and even at this early stage the differences in colonisation levels given by different levels of seed inoculum and by different soils are clearly seen. This early infection was encouraged by high moisture content of all soils at this time. In almost every case the most extensive colonisation tended to be situated towards the lowest part of the stem and the proximal part of the stolons, i.e. nearest to the seed tubers which is the main source and in this experiment almost certainly the only source of inoculum. Here again the minimal infection on symptomless 'free' seed was able to cause stolon infection encouraged by conditions in the heavier soils. In this early infection it appears that there is almost a linear relationship between seed inoculum and stem and stolon infection,

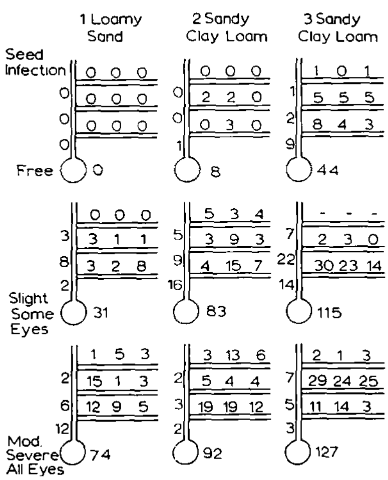

Fig. 3. Colonisation by O. pustulans of stem bases and stolons. Assessment % 8 Oct. 1968.

Abb. 3. Besiedlung durch O. pustulans an Stengelbasen und Stolonen. Beurteilung in %, 8 Okt. 1968. Siehe Abb. 1.
Fig. 3. Colonisation par O. pustulans de la base des tiges et des stolons. Résultat en %, le 8 Oct, 1968. Voir fig. 1.

Table 9. Indices of colonisation by *Oospora pustulans* on stem bases and stolons; *King Edward*, 1968.

Soil[1]	1 Loamy sand[2]	2 Sandy clay-loam[3]	3 Sandy clay-loam	Average[4]
Seed infection[5]				
Free	0	7	18	8
Slight, some eyes[6]	95	104	115	104
Mod./severe, all eyes[7]	104	116	150	123
Average[4]	66	75	95	
Date of sampling[8]				
15 July	62	61	98	74
12 Aug.	74	78	96	83
9 Sept.	94	101	87	94
8 Oct.	35	61	95	64

[1] *Boden – Sol*
[2] *Lehmiger Sand – Limono-sablonneux*
[3] *Schwach toniger Lehm – Sablo-argilo-sablonneux*
[4] *Mittelwert – Moyenne*
[5] *Pflanzgutbefall – Degré d'infection*
[6] *Leicht, einige Augen infektiert – Légère sur quelques yeux*
[7] *Mittel stark, alle Augen infektiert – Modéré sur tous les yeux*
[8] *Datum der Musterentnahme – Date d'échantillonnage*

Tabelle 9. Besiedlundsindex durch *Oospora pustulans* an Stengelbasen und Stolonen; *King Edward*, 1968.
Tableau 9. Index de colonisation par *Oospora pustulans* de la base des tiges et des stolons; *King Edward* 1968.

contrary to the final degree of transmission to the tubers (Table 8) where the slight seed tuber infection provided virtually the optimum transmission.

Fig. 2 gives details of another assessment made on 9 September when haulm growth was beginning to decline. Colonisation by this time had increased in plants from the slightly infected seed but there appeared to be a stabilisation of the areas colonised in plants from severely infected seed. Again the tendency for infection to radiate from the seed tuber is evident.

The data for the last assessment taken on 8 October are shown in Fig. 3. By this time the haulm was senescent or dead, most of the active colonisation had declined and observations were confused by the influence of other causes of stem and stolon discoloration, chiefly *Rhizoctonia* and particularly in the lighter soils. However this was at a minimum in the plants grown from stem cutting material and with this seed in the loamy sand no sign of *O. pustulans* was detected in any samples of stem or stolons. In the second of the two sandy clay-loams the colonisation was considerable and in this soil the decline of active *O. pustulans* was least. Although no infection was detected on the stems or stolons grown from the 'free' seed in loamy sand, the tubers from these plants did show some very slight infection. It is most likely that this descrepancy was due to inadequate sampling and was hardly large enough to suggest that the tuber skin or eye were more sensitive than the stolons.

An index of colonisation was calculated for each treatment simply by addition of the percentage colonisation of the twelve areas of stems and stolons per plant examined in each treatment. The average figures are shown in Table 9.

The same pattern of results was obtained in the following year although conditions were drier and the level of *O. pustulans* was lower throughout.

Discussion

Skin spot seed infection is known to cause blanking and to delay emergence in the resulting plants particularly of *King Edward.* These adverse effects were again noted in this investigation. After planting *Majestic* and *Redskin* seed of comparable infection categories the emergence rate did not differ significantly from that of *King Edward.* Although *Redskin* showed less blanking than the other two varieties the difference was not significant, but is it thought that this may have been influenced by the unusually high incidence of blanking with *Majestic.*

Planting seed with skin spot infection in all eyes does not necessarily result in blanking, and even with *King Edward* more than half of such seed produced plants even in the heavier soil, although the rate of emergence was retarded. *Kerr's Pink* on the other hand showed by its significantly more rapid emergence and its negligible blanking that it was able to overcome comparably severe infection which seriously restricted the growth of the other varieties.

Experimental evidence suggested that little difference occurred in the amount of sprout growth from normal *Kerr's Pink* buds and those which were rendered necrotic by skin spot infection. Little growth occurred from similar necrotic buds of *King Edward* tubers. Field response to skin spot thus may not simply be related directly to eye infection, and the varietal characteristic – which could be described as sprout vigour, until the mechanism can be more clearly defined – must therefore be taken into account when assessing differences in varietal reaction to skin spot.

Evidence was obtained that the type of soil can play an important part in influencing the rate of emergence and also the extent of blanking after planting infected seed. This is possibly due to higher temperatures which are usually associated with lighter soils and which encouraged the sprouts by more rapid extension to overcome the effects of the disease.

No great differences were observed in transmission of infection from a uniform inoculum to tubers of the four different varieties. Thus surface infection indices were very similar but eye infection was slightly lower in *Redskin* and *Majestic* than in *King Edward* and *Kerr's Pink.* This is, of course, in line with the known susceptibility reaction of these varieties but considerably greater variations might have been expected in view of the response of these varieties to uniform artificial inoculation with *O. pustulans* (Nagdy and Boyd, 1965).

The degree of infection of the seed tubers was again shown significantly to influence transmission of the disease to the progeny although the level of transmission was considerably affected by the type of soil, particularly with regard to the eye infection. For example, from a source of minimal inoculum, the eye infection index of tubers in loamy sand was 1.2, while in the sandy clay-loam the corresponding figure was 35.4. Variation in this effect was shown even within the same soil texture group and with a higher proportion of stones greater than 2 mm in a soil with similar sand, silt and clay fractions, the eye infection index was only 8.5. It is possible that in lighter soils transmission is discouraged by a higher degree of aeration and lower moisture retention.

This would be in keeping with the observation (Boyd and Lennard, 1962) that skin spot incidence is generally greater when rainfall is high during the lifting period.

No test for the presence of *O. pustulans* was made with any of the soils used, but if any soil contamination had been present the level must have been low enough not to obscure the influence of seed infection or other factors.

Transmission of infection to the progeny was not directly proportional to the inoculum provided by the seed tubers. This can be seen in Table 8 where the severely affected seed is little more effective in transmission than the slightly affected seed. This can be seen again when the progress of infection on stem bases and stolons is examined. Although the process of infection has not been studied, colonisation of these tissues by *O. pustulans* was well established by mid-July, 6 weeks after planting and this increased to a maximum in most cases up to September. By early October, however, when the plants were becoming senescent, there was a rapid decline of detectable infection, caused partly by invasion of the tissues by *Rhizoctonia*. In the heaviest soil on the other hand, the incidence of *O. pustulans* areas remained at a high level. It is likely that the stem bases and stolons act as inoculum multiplications centres for tuber infection and only the superficial tissues appear to be colonised and discoloured by the fungus.

In some respects transmission of *O. pustulans* is similar to that of *Helminthosporium solani* which causes silver scurf. Both Mooi (1968) and Lennard (1970) found that transmission of *H. solani* was much more extensive from slightly affected rather than severly affected seed. The degree of infection on the crop was dependent on the level of active sporulation on the seed rather than on severity of symptoms. With *O. pustulans* transmission was almost as effective from slightly affected seed as from severely affected seed. On the other hand, infected stem bases and stolons provide an increase in *O. pustulans* inoculum but such a process does not occur with *H. solani*.

The pattern of *O. pustulans* infection of stems and stolons was similar to that of the progeny tubers with regard to the effects of both initial inoculum and soil. The influence of soil type found here is in general agreement with that described by Salt (1964) in the development of *O. pustulans* on stem bases where the highest infection was associated with heavy loam, less with sandy light loam and least with neutral peat (black fen) and alluvial soil. If susceptible varieties are to be grown with the minimum of interference from skin spot attack cultivation in light soils would appear to offer a practicable remedy.

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Zusammenfassung

Reaktionen von Kartoffelsorten auf Infektion mit Tüpfelfleckigkeit (Oospora pustulans) und deren Uebertragung in verschiedenen Böden

Es werden erneut die Einflüsse verschiedener Grade einer Infektion von Pflanzknollen mit Tüpfelfleckigkeit (*Oospora pustulans*) auf das Auflaufen und die Fehlstellen aufgezeigt (Tabellen 2, 3 und 5). Verspätetes Auflaufen und Fehlstellen kamen bei stärkerem Befall des Saatgutes vermehrt vor, waren verstärkt auf schwererem Boden, und bei ähnlich stark befallenem Pflanzgut traten diese Mängel bei *Kerr's Pink* signifikant weniger auf als bei *King Edward*, *Majestic* und *Redskin* (Tabellen 2 und 3).

Das Pflanzenwachstum aus normalen und nekrotischen Knospen von *Kerr's Pink* war sehr ähnlich, aber bei nekrotischen Knospen von *King Edward* wurde praktisch kein Wachstum festgestellt (Tabelle 4). Dies weist darauf hin, dass der Faktor Triebkraft die Reaktion der Sorten auf Tüpfelfleckigkeit im Feld beeinflusst.

Die Krankheitsübertragung auf die Tochterknollen wurde sowohl durch die Pflanzgutinfektion als auch durch die Bodenart (Tabellen 6, 7 und 8) beeinflusst. Die Uebertragung der Krankheit bei der Sorte *King Edward* auf die Stengelbasen und die Stolonen sowie auf die Tochterknollen wurde untersucht (Abb. 1, 2 und 3 und Tabelle 9). Selbst die kleinste Menge Inokulum auf anscheinend freiem Pflanzgut verursachte sowohl eine Stolonen- als auch eine Knolleninfektion, besonders in schwereren Bodenarten. Anderseits übertrug stark infiziertes Pflanzgut in leichtem Boden die Krankheit nur in sehr reduziertem Masse auf die Tochterknollen. Dies würde auf eine Möglichkeit zur Bekämpfung der Krankheit bei anfälligen Sorten hinweisen. Starke Pflanzgutinfektion überträgt die Krankheit wenig mehr als ein schwacher Befall des Pflanzgutes, und wahrscheinlich müssen Stolonen und Stengelbasen als Inokulum-Vermehrungszentren betrachtet werden. Die Besiedlung der Stengelbasen und der Stolonen war im Juli (Abb. 1), 6 Wochen nach der Pflanzung, ziemlich ausgedehnt, stieg zu einem Maximum, in den meisten Fällen im September, an (Abb. 2) und nahm besonders in leichteren Böden ab, wenn die Pflanzen abzusterben begannen (Abb. 3).

Résumé

Réactions des variétés de pomme de terre à l'oosporiose (infection par Oospora pustulans) et la transmission de la maladie dans différents sols.

Les effets de divers degrés d'infection des plants de pomme de terre par l'oosporiose (*Oospora pustulans*) sur la levée et les vides sont à nouveau mis en évidence (tableaux 2, 3 et 5). De hauts niveaux d'infection des plants accroissent le retard de la levée et l'importance des 'non-levée'; les sols lourds intensifient ces accidents; les plants étant infectés au même degré, ces accidents sont significativement moindres chez *Kerr's Pink* que chez *King Edward*, *Majestic* et *Redskin* (tableaux 2 et 3).

Chez *Kerr's Pink* les germes normaux et les germes nécrotiques donnent une croissance très semblable; par contre chez *King Edward*, les germes nécrotiques ne donnent pratiquement aucune croissance (tableau 4). Ceci fait supposer que le facteur 'vigueur des germes' influence la réaction au champ des variétés à l'oosporiose.

La transmission de la maladie aux tubercules-fils est également influencée par l'infection des plants et par le type de sol (tableaux 6, 7 et 8). Les auteurs ont étudié, chez la variété *King Edward*, la transmission de l'infection à la base des tiges et aux stolons, ainsi qu'aux tubercules-

fils (fig. 1, 2, 3 et tableau 9); un minimum d'inoculum sur des plants apparemment sains provoque une infection à la fois des stolons et des tubercules, particulièrement dans les sols lourds. Par contre, en sol léger, des plants sévèrement infectés ne transmettent l'infection à la descendance que dans une mesure très faible. Cette observation suggère une méthode de lutte contre la maladie pour les variétés susceptibles. Une grave infection des plants transmet un peu plus l'infection qu'une infection légère et, vraisemblablement, les stolons et la base des tiges constituent des centres de multiplication de l'inoculum. La colonisation de la base des tiges et des stolons est très importante en juillet (fig. 1), 6 semaines après la plantation, et atteint son maximum dans la majorité des cas en septembre (fig. 2), ensuite diminue, particulièrement en sols légers, au moment où les plantes vieillissent. (fig. 3).

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