

SOME NEW RACES OF *PUCCINIA STRIIFORMIS*¹

Enkele nieuwe fysio's van Puccinia striiformis

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In the Netherlands in 1961 three new field races were found of *Puccinia striiformis*, the causal fungus of yellow rust on wheat. Two of these, viz. the 'Falco' race and the 'Opal' race, together with the already known 'Etoile de Choisy' race, constitute the so-called Nord-group of races, which is now clearly distinguished from the so-called Rubis-group. Most dangerous and interesting is the third of the new races. This so-called 'Cleo' race proved to be the first to break both resistance to the Nord-group and resistance to the Rubis-group. On wheat seedlings in the greenhouse all three new races behaved like greenhouse race 'W(ageningen) 8' = 'B(raunschweig) 55'.

INTRODUCTION

In the Netherlands in 1961 some crops of wheat varieties which had so far been resistant to yellow rust (*Puccinia striiformis* Westend.), were found to be rather severely infected by this disease (ZADOKS & UBELS, 1961). An examination of the fungus isolates made from these cases, proved the occurrence of three new races. These races are particularly interesting because their characteristics throw a new light on the physiologic specialization of yellow rust in W. Europe. Thus the new data given in this article are an important supplement to the survey of the West European races of the parasite published by ZADOKS (1961). Especially important, both from a scientific and practical point of view, is the race which was found on the variety 'Cleo' for the first time in 1961.

OCCURRENCE

The previously resistant wheat varieties which were infected for the first time in 1961 are the varieties 'Cleo', 'Falco' and 'Opal'. 'Falco' and 'Opal' were infected only in the IJsselmeer-polders: 'Falco' was severely attacked in some fields in Oost-Flevoland and in the Noord-Oost-Polder, while infection of 'Opal' was observed in one case only – at a breeder's farm in the Noord-Oost-Polder.

Since 1961 natural infection of 'Falco' has not been found again. However, the variety has never become very popular and its susceptibility to yellow rust found in 1961, was one of the reasons why it was no longer included in the 1964 List of Varieties of Agricultural Crops in the Netherlands. New infections of 'Opal' were not found until some light cases in 1964. But it has not yet been established whether the race concerned is the same as that found on this variety in 1961.

In 1961 the variety 'Cleo' was infected only in the western part of the country, the infection occurring in three different places scattered from north to south. During the winter of 1961/62 the yellow rust population was markedly reduced

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in most parts of N.W. Europe (UBELS, 1962; UBELS & FUCHS, 1964). Accordingly spontaneous infections by yellow rust were rare in the Netherlands in 1962. Nevertheless they included infection of the variety 'Cleo', again only in the western part of the country and quite severe in places. In 1963, after a severe winter, no yellow rust was found in commercial wheat crops at all. But in 1964 infection of 'Cleo' was observed in several places, mainly in the south-west of the country, but now for the first time in an eastern area as well, viz. the Noord-Oost-Polder. In both areas several hectares of 'Cleo' were severely affected, while the race in question was also found to be present in various surrounding fields. So during the period 1962-1964, which was generally not very favourable to yellow rust, this race was practically the only one which maintained its ground and even managed to spread.

INFECTION SPECTRA

ZADOKS (1961) distinguished six "greenhouse races" (or rather: youth races) in yellow rust on wheat in N.W. Europe, which could again be subdivided into fifteen "field races" (or rather: mature plant races). The differences between the greenhouse races as regards their attack on wheat varieties only concern the reactions of seedlings (greenhouse tests), whereas with the field races we are concerned with the reactions of mature plants (usually in the field). The distinction between greenhouse races and field races is thus connected with the fact that we may find resistance or susceptibility in all growth stages, but also resistance in the early stages followed by susceptibility in the mature stage. Field races are thus further differentiated than greenhouse races, and one greenhouse race usually comprises several field races.

However, the infection characteristics of certain of the field races, published by ZADOKS in 1961, were based on a limited number of observations, as appears from their "weights". In some cases the data even concerned one season or one field only. For that reason the races from ZADOKS' collection have been re-tested several times in race nurseries since 1961. The isolates from 'Cleo', 'Falco' and 'Opal' were also included in these tests. Moreover many wheat varieties which had not been tested before for their differentiating abilities were included. The results from the race nurseries in 1962 and 1963 combined with ZADOKS' data of 1961 are presented in Table 1. The results from the race nurseries in 1964 were not yet available when this article was compiled.

Some of the races mentioned by ZADOKS, but whose existence has not yet been conclusively proved, have been omitted from Table 1. This table distinguishes four groups of races. The races of the first and the fourth group have already been described by ZADOKS (1961). Since then little has been changed as regards their characteristics and compatibility-indices. The data collected during the last few years mainly confirm the data published on these races in 1961.

The second and third columns of the table relate to new races and their infection figures. It is true that the 'Etoile de Choisy' race was already known in 1961, but the data on this race then published by ZADOKS were inadequate. This becomes apparent when comparing ZADOKS' data with those in Table 1. Infection figures clearly demonstrating the individual character of this race, were obtained by ZADOKS, but not until the end of 1961 from the results of that year's race nurseries (ZADOKS, 1962). In the following years the characteristics of this

TABLE 1. Characteristics of the field races of yellow rust of wheat (*Puccinia striiformis*) in N.W.Europe. Entries are compatibility indices (measure of the degree of attack on mature wheat plants, scale 1–100; see ZADOKS, 1961), calculated from all data available at the end of 1963.

Karakteristieken van de veldfysio's van de gele roest van tarwe (Puccinia striiformis) in N.W.Europa. De getallen zijn de compatibiliteitsindices (maat voor de aantasting van volwassen tarweplanten, schaal 1–100; zie Zadoks, 1961), berekend uit alle ultimo 1963 beschikbare gegevens.

Field races ¹ of the fungus <i>Veldfysio's</i> <i>van de schimmel</i>	'Flamingo'	'Peko'	'Leda'	'Heine's VII'	'Heine's Kolben'	'B 26'	'Etoile de Choisy'	'Opal'	'Falco'	'Cleo'	'Chinese'	'Dippes Triumph'	'Alba'	'B 55'	'B 8'
Differentiating wheat varieties <i>Differentiërende tarwerassen</i>															
'Rubis'	89	84	84	92	18	26	1	1	1	95	1	1	1	0	1
'Little Club'	79	66	90	88	83	54	1	2	1	90	2	2	1	1	1
'Merlin'	39	40	58	38	0	1	0	0	0	23	0	1	0	0	0
'Heine's VII'	37	47	60	46	0	1	0	0	0	22	0	0	0	0	0
'Heine's Kolben'	57	56	1	1	80	0	0	0	0	3	0	0	0	0	0
'Peko'	23	34	1	0	12	0	0	0	0	2	0	0	0	0	0
'Heine's IV'	37	1	46	7	0	0	0	0	0	0	0	17	0	0	0
'Flamingo'	35	1	5	1	3	0	0	0	0	0	0	0	0	0	0
'Leda'	1	0	33	0	0	0	0	0	0	0	0	0	0	0	0
'Nord Desprez'	0	0	0	0	3	2	38	49	44	57	0	1	0	4	0
'Lille'	.	.	0	1	.	1	59	55	45	34	7	0	1	4	0
'Vilmorin 23'	0	0	0	1	0	2	23	24	38	21	0	3	0	3	0
'S 80'	.	.	0	0	.	0	32	42	44	40	1	2	0	2	0
'Falco'	1	1	5	1	28	4	13	13	38	18	1	5	4	13	2
'Mado'	0	0	2	0	1	0	1	5	45	7	0	0	6	2	0
'Etoile de Choisy'	0	1	2	1	0	1	30	4	5	4	1	1	1	2	2
'Marne'	1	0	0	0	0	1	26	5	4	2	0	0	0	1	0
'Carest'	0	0	0	0	0	0	30	1	0	0	0	0	0	1	0
'Opal'	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0
'Carpo'	0	0	0	0	0	0	3	31	0	1	0	0	0	0	0
'Alba'	2	7	25	7	8	7	5	19	49	18	0	0	54	19	0
'Cleo'	0	2	3	2	44	1	0	0	0	49	0	0	0	0	0
'Minister'	0	0	0	0	3	0	0	0	0	30	0	0	0	0	0
'Marchal'	6	2	16	12	1	0	0	2	0	20	1	0	0	0	0
'Dippes Triumph'	2	0	5	3	0	0	3	0	0	0	1	51	1	0	5
'Chinese 166'	0	1	0	0	0	0	0	0	0	0	89	0	0	0	0
'Carsten V'	0	8	0	0	0	0	0	.	.	.	21	0	0	0	0
Weight ² <i>Gewicht</i>	5;8	4;7	4;4	4;14	2;5	3;4	4;9	2;2	2;3	2;3	4;6	4;36	6;7	3;8	3;4
	25	17	13	38	14	13	17	6	8	10	13	70	13	19	7

¹ A field race is in most cases called after the wheat variety on which it occurs most frequently or on which it was first noticed, usually because it broke this variety's resistance. / *Een veldfysio wordt veelal genoemd naar het tarweras waarop het het meest voorkomt of waarop het het eerst werd opgemerkt, meestal omdat het de resistentie van dit ras doorbrak.*

² Of the three figures of the weight the first indicates the number of years, the second the number of trials, and the third the number of observation sets on which the characteristic is based. / *Van de drie getallen van het gewicht geeft het eerste aan het aantal jaren, het tweede het aantal proefvelden en het derde het aantal waarnemingsreeksen waarop de karakteristiek gebaseerd is.*

. = No data available / *Geen gegevens beschikbaar.*

Field race 'B 8' affects only wheat varieties highly susceptible to all field races of yellow rust; it therefore does not affect any of the differentiating varieties mentioned in the table. / *Veldfysio 'B 8' tast alleen de tarwerassen aan die zeer vatbaar zijn voor alle veldfysio's van de gele roest en dus geen van de differentiërende rassen van de tabel.*

race have been further supplemented and improved, resulting in the data shown in Table 1.

Now that the distinguishing characteristics of the 'Etoile de Choisy' race have been improved and the characteristics of the isolates from 'Opal', 'Falco' and 'Cleo' have become known, a clear distinction has emerged between the so-called Rubis-group (ZADOKS, 1961) and the so-called Nord-group (ZADOKS & UBELS, 1962) of races. This distinction is shown clearly in Table 1.

The Rubis-group is characterized by compatibility with the varieties 'Rubis' and 'Little Club'. It comprises the races 'Flamingo', 'Peko', 'Leda', 'Heine's VII', 'Heine's Kolben' and 'B 26'. The Nord-group comprises the 'Etoile de Choisy' race and the two new races infecting 'Opal' and 'Falco' in 1961. This group is characterized by compatibility with a number of French varieties, viz. 'Nord Desprez', 'Lille' and 'Vilmorin 23' and with the English variety 'S 80'. This group too has its own differentiating varieties which demonstrate the variations within the group. Other varieties which are susceptible to all races of the Nord-group are the well-known 'Cappelle Desprez' and 'Staring', not included in the table.

The differentiating varieties of Table 1 enable us to make a sharp distinction between the Rubis-group and the Nord-group. In all cases we find that the differentiating varieties which are susceptible to one or more races of one group, are without exception resistant to all races of the other group.

The most important new item, well shown in the table, is the fact that the 'Cleo' isolate infects 'Rubis', 'Little Club', 'Merlin' and 'Heine's VII' as well as 'Nord', 'Lille' and the other varieties typically susceptible to the Nord-group of races. Moreover some varieties are affected which are resistant both to the Rubis-group and to the Nord-group, such as 'Cleo', 'Minister' and 'Marchal'.

The relationship between the 'Opal' and 'Falco' races and the 'Etoile de Choisy' race was also shown by their reactions on seedlings in the greenhouse. On seedlings of a differential set consisting of the varieties 'Vilmorin 23', 'Heine's Kolben', 'Carstens V' and 'Chinese 166' (ZADOKS, 1961), both these

TABLE 2. Relation between greenhouse races and field races of yellow rust of wheat (*Puccinia striiformis*) in N.W.Europe.
Het verband tussen kasfysio's en veldfysio's van de gele roest van tarwe (Puccinia striiformis) in N.W.Europe.

Greenhouse races <i>Kasfysio's</i>		Field races ¹ <i>Veldfysio's</i>
Wageningen Nos. Holland	Braunschweig Nos. Germany/ <i>Duitsland</i>	
4	1x	'Heine's Kolben' 'B 55', 'E. de Choisy', 'Opal', 'Falco', 'Cleo'
8	55	
12	54	'Flamingo', 'Peko'
13	53	'Chinese'
14	26	'B 26'
16	8	'B 8', 'Alba', 'D. Triumph'
(16)	8	'Heine's VII', 'Leda'

¹ See note 1 at the bottom of Table 1./*Zie voetnoot 1 bij tabel 1.*

races, as well as the 'Cleo' race, were found to belong to greenhouse race 'W 8'. With this supplement to the data supplied by ZADOKS (1961), ZADOKS & UBELS (1963) and UBELS & FUCHS (1964), a survey may be compiled showing the relation between field races and greenhouse races of yellow rust on wheat in N.W. Europe (Table 2).

IMPORTANCE

The most important of the newly found races is the 'Cleo' race, because it is capable of attacking a larger number of wheat varieties than any other yellow rust race in N. W. Europe.

Of the 23 wheat varieties which are included in the 1964 List of Varieties of Agricultural Crops in the Netherlands there are at least nine which are susceptible to the 'Cleo' race, with highest degrees of infection ranging from 6 to 9 (International Scale). They are the winter wheat varieties 'Cleo', 'Cappelle Desprez', 'Heine's VII', 'Hector', 'Stella', 'Sambo', 'Mado' and 'Wodan' and the spring wheat variety 'Jufy I'. In 1963 these varieties together took up over 20% of our total wheat acreage. Moreover the race proved to overwinter quite easily, and in 1964 was found to be present in many places in this country. So it is clear that notwithstanding the large number of varieties which are grown at present, this 'Cleo' race is a real danger to a considerable part of our annual wheat crop.

In these circumstances it is imperative that breeding for resistance to yellow rust should be continued intensively. In view of the exceptionally wide infection spectrum of the 'Cleo' race, the breeding program should be on a very wide genetic basis.

As was to be expected from its wide infection spectrum, the 'Cleo' race has been found to be especially important to our knowledge of the physiologic specialization of *Puccinia striiformis*. Further research into this aspect is in progress.

SAMENVATTING

Er zijn van de schimmel *Puccinia striiformis* Westend., de veroorzaker van de gele roest van tarwe, in Nederland in 1961 drie nieuwe veldfysio's gevonden. Dit zijn het 'Falco'-fysio, het 'Opal'-fysio en het 'Cleo'-fysio. De eerste twee bleken met het reeds bekende 'Etoile de Choisy'-fysio een groep te vormen, de z.g. 'Nord'-groep, die zich duidelijk onderscheidt van de reeds beter bekende 'Rubis'-groep van fysio's. Eerstgenoemde groep kenmerkt zich o.a. door de aantasting van het tarweras 'Nord', de laatstgenoemde door de aantasting van 'Rubis' (zie tabel 1). Het belangrijkste en het gevaarlijkst is het 'Cleo'-fysio. Dit bleek voor zover bekend het eerste en enige fysio te zijn dat zowel de resistentie tegen de 'Rubis'-groep als die tegen de 'Nord'-groep doorbreekt. Het heeft zodoende een zeer breed aantastingspectrum. Van de tarwerassen die voorkomen in de 39ste Nederlandse Rassenlijst voor Landbouwgewassen (1964) zijn de volgende negen rassen vatbaar voor het 'Cleo'-fysio met een aantastingsgraad van 6 tot 9 (Internationale Schaal): 'Cleo', 'Cappelle Desprez', 'Heine's VII', 'Hector', 'Stella', 'Sambo', 'Mado', 'Wodan' en 'Jufy I'. Bovendien bleek het 'Cleo'-fysio in vergelijking met de andere veldfysio's goed te overwinteren en in 1964 reeds op vele plaatsen in Nederland aanwezig te zijn. Het 'Cleo'-fysio maakt het des te noodzakelijker bij de selectie op resistentie tegen gele roest te

werken op een brede genetische basis. Bij toetsing op tarwekiemplanten in de kas gedroegen de drie nieuwe fysio's zich alle als het kasfysio 'W(ageningen) 8' = 'B(raunschweig) 55' (zie tabel 2).

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