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THE VARIABLE STRIPE RUST REACTION OF THE WHEAT CULTIVAR CHAMBORD

BY V. SLOVENČÍKOVÁ

Research Institutes of Crop Production, Praha-Ruzyne

The wheat cultivar Chambord has been considered as resistant to all known stripe rust races both in the seedling and adult stage. We have found variation of the seedling reaction in the greenhouse during various seasons of the year.

MATERIALS AND METHODS

The seedlings of parental cultivars and crosses were tested in an air-conditioned greenhouse in which temperature varied around 15°C. In the field and greenhouse tests we used the race 3/55 Opal (40E9). In each pot we seeded five plants of the susceptible check Michigen Amber. Reaction types 2 and 3 were classified as susceptible. Chambord was crossed with the susceptible cultivar Fakir and with Mildress, the resistance of which is probably derived from rye (Ellis, 1971). The resistance of Kavkaz is also derived from rye (Valkoun et al., 1973).

RESULTS AND DISCUSSION

Bever (1934), Gassner (1915), Manners (1950), Stubbs (1967), Fuchs (1965), Sharp & Volin (1970) and Slovenčíková (1972), demonstrated the effect of light and temperature on the stripe rust reaction. The influence of seasonal differences, and in particular, differences in light intensity were observed in the cultivar Chambord. In late autumn and winter when the light intensity was low, we found some plants susceptible and some resistant. Differences in the reaction of single plants were found for example in one pot. We suppose that differences of light supply in individual plants influenced their reaction type. Under field conditions all adult plants of this variety were resistant to stripe rust. Segregation for resistance in the greenhouse tests of the F_2 progeny of the cross Fakir x Chambord also showed environmental effects, in particular those of light intensity on the expression of the resistance of Chambord. With increasing light intensity the number of resistant plants increased.

Segregation for resistance in adult plants of the crosses Kavkaz x Chambord and Mildress x Chambord indicated two dominant genes: one dominant gene in Kavkaz or Mildress and one dominant gene for resistance in Chambord. One dominant gene for resistance was indicated in the F_2 progeny of Fakir x Chambord. The group of the plants evaluated as susceptible included also plants with infection type 2. This may indicate the effect of a more complex genetic system in Chambord.

We continue our tests of F_2 and F_3 families in the greenhouse and under field conditions.

Table 1. Tests of F_2 progenies in the seedling stage.

Cross and Date of infection	Obs. No. of plants of each infection type: 0	2	3	Total	Obs. ratio Resis.:susc.
A. Before and after inoculation in greenhouse.					
Fakir x Chambord					
23.10.1972 (late autumn)					
Fakir			18	18	
Chambord	5	2	11	18	
F_2	43		250	293	43:250
17.1.1973 (winter)					
Fakir			15	15	
Chambord	7	8	10	25	
F_2			297	297	0:297
28.3.1973 (early spring)					
Fakir			15	15	
Chambord	10	3	5	18	
F_2	11	11	121	143	11:132
B. Before and after inoculation in controlled environment.*					
30.4.1973					
Fakir			20	20	
Chambord	7	3	2	12	
F_2	17	16	63	96	17:79
C. Before inoculation in greenhouse, after, in controlled environment.					
Fakir			15	15	
Chambord	15			15	
F_2	58	8	124	190	58:132

*The controlled environment: 15°C, 16 hour day, (fluorescent tubes giving 3500-4000 Lx).

Table 2. Tests of F_2 progenies of adult plants in the field nurseries.

Cross	Obs. no. of plants of each infection type			Total	Expec. ratio	P value
	0	2	3			
Fakir			50	50		
Chambord	50			50		
F_1 Fakir x Chambord	26			26		
F_2 Fakir x Chambord	155	39	11	205	3:1	0.90-0.80
Kavkaz	50			50		
Chambord	50			50		
F_1 Kavkaz x Chambord	8			8		
F_2 Kavkaz x Chambord	153	5	5	163	15:1	0.90-0.80
Mildress	50			50		
Chambord	50			50		
F_1 Mildress x Chambord	5			5		
F_2 Mildress x Chambord	207	12	-	219	15:1	0.70-0.50

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REACTIONS OF SEEDLINGS OF WHEAT VARIETIES AND LINES FROM THE ROMANIAN BREEDING PROGRAMME AT FUNDULEA TO BRITISH ISOLATES OF PUCCINIA STRIIFORMIS

BY F. NEGULESCU*

Institute of Cereal and Technical Crops, Fundulea, Romania

AND R. JOHNSON

Plant Breeding Institute, Cambridge, England

Forty-two varieties and lines of wheat from a breeding programme at Fundulea, Romania, were grown at the Plant Breeding Institute, Cambridge, England, in potting compost in 7.5 cm plastic pots. When the first leaf was fully expanded and the second leaf was emerging, the plants were lightly sprayed with distilled water and inoculated with uredospores of *Puccinia striiformis* Westend. dispersed in talc. Ten groups of 42 pots were each inoculated with a different isolate and placed in airtight aluminium containers with 2 cm depth of water, transferred to a refrigerator at 7°C for 24h to encourage infection and then returned to the glasshouse bench. Infection types were scored according to the 00 to 4 scale of Gassner & Straib (1932) approximately 2 weeks after inoculatio

Twenty-two lines and varieties were resistant to all the isolates (Table 1) and eighteen of these have the variety Neuzucht in their pedigrees (Table 3). Neuzucht originated from crosses between wheat and rye in the breeding programmes of Riebesel and is probably identical or very similar to Salzmünde 14/44 (=Salmünder Bartweizen) (Lein, 1973; Zeller, 1973) in which chromosome 1B of wheat is substituted by chromosome 1R from rye. The alien rye chromosome confers resistance to rust diseases and mildew (Bartoš & Bares, 1971; Zeller, 1973) and is almost certainly the cause of resistance to *P. striiformis* in all the eighteen resistant lines and varieties. Of the remaining four lines and varieties resistant to all isolates Burgas 1 has been shown by Worland (personal communication) and Burgas 2, Lovrin 10 and Lovrin 13 by Mettin, Blüthner & Schlegel (1973) and Bartoš, Valkoun, Kosner & Slovenčíková (1973*a*) to possess, instead of the usual two pairs, only a single pair of satellited chromosomes. Mettin *et al*. (1973) suggest that this is a useful karyological marker for plants with the 1B/IR chromosome substitution.

It is probable, therefore, that the observed resistance to *P. striiform* in all twenty-two highly resistant lines and varieties is derived from the same rye chromosome 1R. Although this type of resistance is relatively new in wheat breeding programmes (Lein, 1973) there is evidence that the rust pathogens can produce physiologic races capable of overcoming it. The variety Aurora which carries resistance to *P. recondita* derived from rye chromosome 1R (Zeller, 1973) was seriously attacked by leaf rust in 1973 in Romania (Negulescu & Ionescu-Cojocaru, 1974). In addition to the varieties mentioned here many other recently developed varieties including Orlando, Weique and Riebesel 47/51 carry resistance to rust disease due to

*The work was carried out during tenure of an FAO Travelling Fellowship at the Plant Breeding Institute, Cambridge, by F. Negulescu in 1973.

Table 1. Resistant reactions of seedlings of varieties and lines from the Romanian wheat breeding programme at Fundulea to races of *Puccinia striiformis*

Variety or line		Races									
	New name[1]	37E132	40E8	41E136	41E136	104E9	104E137	104E137	108E9	108E141	108E141
	Old name	60	2B	58C	58C	3/55 Opal	3/55D	3/55D	1B	-	-
	Isolate[2]	66/33/21	319SS	68/1	72/40	66/79/31	69/10	71/2	70/2	72/10	72/55
1 Aurora		0^{n}	0^{n}	$1-1^{+}$	0^{n}	0^{n}	0-1	0^{n}	0^{n}	0^{n}	$0-1^{-}$
2 Kavkaz		$00-0^{n}$	0^{n}	$0-1^{-}$	0^{n}	0^{n}	0^{n}	0^{n}	0^{n}	0^{n}	0
3 F158-69		$0-1^{-}$	$0^{n}-1$	$0-1^{-}$	$0^{n}-1$	$0-1^{-}/3^{3}$	0-1	0^{n}	$0-1^{-}$	0^{n}	1^{-}
4 F35-70		0^{n}	0^{n}	$0-1^{-}$	0^{n}	0^{n}	$0-0^{n}$	0^{n}	0^{n}	0^{n}	$1-2^{+}$
5 F36-70		0^{n}	0^{n}	$0-1^{-}$	0^{n}	0^{n}	0^{n}	0^{n}	0^{n}	0^{n}	0-1
6 F43-70		$0-0^{n}$	0^{n}	$0^{n}-1$	0^{n}	0^{n}	0	0^{n}	$0^{n}-1^{-}$	0^{n}	0
7 F44-70		$00-0^{n}$	00	0	0^{n}	00	0-00	00	00	00	0-00
8 F49-70		1^{-c}	0^{n}	$0-1^{-}$	0^{n}	$0^{n}-1/3^{-}$	$0-2/3^{-}$	0^{n}	0-1	0^{n}	$1-2^{+}$
9 F3-71		0	0^{nc}	$00-1^{-}$	0^{n}	0^{n}	0-1	0^{nc}	00-1	0^{n}	$0-2^{+}$
10 F1-71		0	0^{n}	0	0^{n}	0	0^{n}	0^{n}	0	0^{n}	$0^{cn}-1^{c}$
11 F21-71		0^{c}	0^{c}	$0-1^{-}$	$0^{n}-1$	$0^{n}-1^{n}$	$0-0^{n}$	0^{c}	0^{n}	0^{n}	$0-1^{+}$
12 F25-71		00-0	00	0	0^{c}	00	00	00	0	00	00
13 F26-71		1^{-}	0^{c}	$0-1^{-}$	1^{-}	0-1	0^{c}	1^{n}	0-1	0^{n}	$0-1^{-}$
14 F110-71		00	00	00-0	00	0^{n}	0^{n}	00	00	00	0
15 F113-71		00-0	00	0	00	0	00	00	00-0	00	0
16 F118-71		0	00	0	0^{nc}	0	00	0^{n}	0	00	0
17 F119-71		0^{n}	0^{c}	0^{n}	0^{c}	0^{n}	0^{c}	0^{nc}	0^{c}	0^{n}	0^{c}
18 F146-71		0^{n}	0^{n}	0^{n}	0^{nc}	0^{n}	0^{n}	0^{n}	0^{n}	0^{n}	0^{nc}
19 Burgas 1		0^{n}	00	$0-1^{-}$	0^{n}	0^{n}	0^{n}	0^{n}	0	0^{n}	$0-1^{-}$
20 Burgas 2		0	0^{c}	$0-1^{-}$	0^{n}	$0^{n}-1$	0	0^{n}	1^{n}	0^{n}	1^{-}
21 Lovrin 10		0	0^{c}	$0-1^{-}$	0^{n}	0^{n}	$0-0^{n}$	0^{n}	0^{n}	0^{n}	$0^{c}-1^{-}$
22 Lovrin 13		0^{n}	00	$0-1^{-}$	0^{nc}	0^{n}	0^{n}	0^{n}	00	0^{n}	0^{c}

1, 2, 3: For key to notes, see Table 2.

Table 2. Susceptible and differential reactions of seedlings of varieties and lines from the Romanian wheat breeding programme at Fundulea to races of *Puccinia striiformis*

Variety or Line	Races: Name[1] / Isolate[2] 37E132 66/33/21	40E8 319SS	41E136 68/1	41E136 72/40	104E9 66/79/31	104E137 69/10	104E137 71/2	108E9 70/2	108E141 72/10	108E141 72/55
23 Arthur	3-4	3^+	4	3-4	3	4	3^+-4	3^-	3^+	4
24 Bezostaia 1	3^-	1-2	4	0^n-4^-	$1-3^-$	4	$1-3^-$	0-2	3	4
25 Dacia	4	00-1	4	3^+	$1-2^+$	4	3^+	0-1	3^+	4
26 Dneprovski 521	2-3	3	3^+	3^+	3^-	3^--4	2^+-3	3^-	3	3^+
27 Excelsior	4	$0^n/3-4$[3]	4	4	3^-	4	3	0-1/3	3^+	4
28 Favorit	3-4	0^n	3^+	3^+	1-2	4	$3\pm$	0-1	3^+	4
29 Maliani 8D	1^+-2	1^+	2^+	1	2	1^+	0^n-1	2^-	1	2^+-3^-
30 Moldova	4	$0^n/3$	4	4	3^-	4	3^+	3^-	3^+	4
31 MV.69-06	$3\pm$	2-3	4	3^-	3^+	4	$3^\pm$	3^-	3	4
32 Novi-Sad 60	4	0^n	4	3^+	0-2/3	4	3^+-4	0^n-1	3^+	4
33 Novi-Sad 732	3-4	3^+	4	3^+	3-4	4	3^+-4	$3^\pm$	3^+	4
34 Odessa 51	1-2/4	3	4	$2-3^+$	$3^\pm$	4	0^n-3^+	$3^\pm$	$2-3^-$	3^+-4
35 Zlatna-Dolina	4	4	4	3^+	3^+	4	4	3^+	4	4
36 F369-65	3-4	3	4	$2-3^+$	3^-	4	$1-3^+$	3	3	3
37 F26-67	1-2/3	$1^-/3^-$	4	1^+-2	3	4	$2-3^-$	0-1/3	3^+	3-4
38 F53-67	$0^n/3^+$	$0^n/3^-$	0/4	$0^n/3^-$	0-1/3	$0^n/4$	$0^n/3^+$	0-1/3	$0^n/3^+$	0/4
39 F133-67	3	00	4	3	0^n-1	4	3	0^n-1^+	3	3-4
40 F157-67	2-3	0^n-1	4	2^+	$1-3^-$	4	3	$1-3^-$	1-3	3-4
41 F51-68	$0-2^+$	0^n-1	4	2^+-3	$0-3^-$	4	0^n-3^-	0-2	1-3	4
42 F216-68	$3^\pm$	3	4	2^+-3	2^+-3	4	3^-	3	3	4

1. Nomenclature according to Johnson, Stubbs, Fuchs & Chamberlain (1972)
2. Isolates in the Plant Breeding Institute collection of *P. striiformis*
3. / indicates segregation in reaction classes

Table 3. Pedigrees of 42 varieties and Romanian lines

	Varieties and lines	Pedigrees
	Resistant to yellow rust with Neuzucht in their pedigree	
1	Aurora	Neuzucht x Bezostaia 4 x Bezostaia 1
2	Kavkaz	Neuzucht x Bezostaia 4 x Bezostaia 1
3	F158-69	Neuzucht x Bezostaia 1
4	F35-70	Bezostaia 1 x Produtore x Aurora
5	F36-70	Bezostaia 1 x Produtore x Aurora
6	F43-70	Neuzucht x Bezostaia 1
7	F44-70	Neuzucht x Bezostaia 1
8	F49-70	Neuzucht x Bezostaia 1
9	F1-71	Neuzucht x Bezostaia 1
10	F3-71	Neuzucht x Bezostaia 1
11	F21-71	Neuzucht x F6-62
12	F25-71	Neuzucht x F342-62
13	F26-71	Neuzucht x F342-62
14	F110-71	Neuzucht x Bezostaia 1
15	F113-71	Neuzucht x Bezostaia 1
16	F118-71	Neuzucht x F194-62
17	F119-71	Neuzucht x F342-62
18	F146-71	Neuzucht x F342-62
	Resistant to yellow rust with one pair of satellited chromosomes	
19	Burgas 1	?
20	Burgas 2	?
21	Lovrin 10	Abondanza x Triumph x Bezostaia 1
22	Lovrin 13	Heine VII x Skorospelka 3b
	Susceptible or differentiating lines and varieties	
23	Arthur	?
24	Bezostaia 1	Lutescens 17 x Skorospelka 2
25	Dacia	Bucuresti 1 x Skorospelka 3b
26	Dneprovski 521	Ukrainka x Elymus x Bezostaia 1
27	Excelsior	Bucuresti 1 x Skorospelka 3b
28	Favorit	Odvos 241 x Bezostaia 4
29	Maliani 8D	?
30	Moldova	Bucuresti 1 x Skorospelka 3b
31	MV 69-06	?
32	Novi-Sad 60 (Dunav)	Heine VII x 129 Genus
33	Novi-Sad 732	S13 x Aobakomugi
34	Odessa 51	Bezostaia 4 x Odeskaia 16
35	Zlatina-Dolina	414-57 x Leonardo
36	F369-65	Fiorello x Bezostaia 1
37	F26-67	Bezostaia 4 x Funone
38	F53-67	Kanred x Funo
39	F133-67 (Iulia)	Beloterkovskaia 198 x Bezostaia 1
40	F157-67 (Ceres)	Miciurinka x Bezostaia 1
41	F51-68	Miciurinka x Bezostaia 1
42	F216-68	Beloterkovskaia 198 x Bezostaia 1

the same rye chromosome (Bartoš *et al*., 1973*a*, *b*; Mettin, Blüthner & Schlegel, 1973; Zeller & Fishbeck, 1971; Zeller & Sastrosumarjo, 1972; Zeller, 1973). It is possible that too much reliance upon this single source of resistance to these diseases has developed in some European breeding programmes, perhaps constituting an example of genetic vulnerability (National Academy of Sciences, 1972).

Of the remaining varieties most gave a type 4 reaction to at least some of the isolates (Table 2). There is evidence of differential resistance in some varieties, such as Bezostaia 1 and, for example, line F133-67 (number 39) which gave reactions between 0 and 2 to races 40E8, 104E9 and 108E9. Further tests would be required to confirm these differential reactions, and to study the relationship between seedlings and adult plant reactions. There may be valuable resistance which would be genetically distinct from that due to rye chromosome 1R in some of the varieties which are susceptible as seedlings.

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A CHARACTER DESIGNATION OF THE HOST IN HOST: PARASITE SYSTEMS AND A REPRESENTATION OF THE CORRESPONDING GENES

BY A.P. do CARMO e FREITAS

Estação Agronómica Nacional, Oeiras, Portugal

In order to promote a better understanding of the genetic interactions in parasite: host systems in which a gene-for-gene hypothesis (Flor, 1955) is applicable, it is appropriate to consider characters of both the organisms in association and to aim at a universal system representing corresponding genes in the host and in the parasite.

Suggestions concerning these matters have already been made (Freitas & Freitas, 1972). However it seems useful to explain with more detail the basic determinant reasons for these suggestions.

PATHOGENICITY AND RECEPTIVITY

Considering the parasitic type of symbiotic system (Read, 1970) to which the gene for gene hypothesis has been considered applicable, the results of the host: parasite association depend on the interactions of the specific genes of each of those organisms.

The term "pathogenicity" has been used (Loegering & Powers, 1962; Loegering, 1972) for the specific parasite character and its genotype is one of the determinants of the result of the interaction. Similarly the concept of "receptivity" was suggested for the specific host character in order to represent its own capability of accepting the parasite in association (Freitas & Freitas, 1972).

The adoption of the terms "pathogenicity" and "receptivity" when dealing with the genetics of such associations, resulted mainly from the following considerations:

- The terms "resistance" and "susceptibility" for the host, as well as those of the "avirulence" and "virulence" for the parasite, have already been pointed out as being a source of confusion (Loegering, 1971).
- The character designations conditioning, through their genotypes, the behaviour of a host: parasite system must be not only specific for each organism in association, but also independent of the designation of the result obtained by the interaction.
- "Reaction" cannot be considered a very good word for the specific host character because it is a universal concept and if used in that sense it may suggest restriction of this characteristic in the parasite. Besides this designation could give the idea of preponderance of the host character on the result of the association.
- There is the need of a single, direct and specific concept for the host character, as well as the one which already exists for the parasite ("pathogenicity").
- The specific host character needs to include low (r r) and high R -) genotypes comparable to Loegering's concept of "relative low and high", either in pathogenicity, as a specific character of the parasite, or in infection type, as the result of the interaction (Loegering, 1972).

- The host character is as important as the parasite character in influencing the result in a parasitic system to which the gene-for-gene hypothesis is applicable. So, if the specific characters in the host and in the parasite are parallel, the designations of these genes need to show the clear similarity in the behaviour of the two organisms which in association.

- The designations must facilitate the genetic analysis of the interaction results.

- Low receptivity in the host, and low pathogenicity in the parasite, are separately necessary conditions but either alone is not sufficient to produce a low infection type. If either high receptivity or high pathogenicity is present, a high infection type will always be the final result of the interaction.

NOMENCLATURE OF GENES

A representation of corresponding genes conditioning infection types in host: parasite associations, in which the gene-for-gene hypothesis is applicable (Flor, 1955) was suggested by Freitas & Freitas (1972). "Pmn:H" will represent an allele for pathogenicity _n_ at the locus _m_ with reference to a specific host: parasite association (symbols _H_ and _P_). The corresponding gene for receptivity will be represented by "Hmn:P".

This system of gene representation resulted mainly from the following considerations:

- There is need for a gene representation system which is generally useful for all the parasitic associations to which Flor's hypothesis is applicable.

- Although genes for receptivity and for pathogenicity are corresponding genes, they are distinct and so need to have different representations.

- The genes bear reference to the phenotype produced when in the homozygous condition.

- In such a parasitic system, the phenotype is not confined to a single character but is the resultant of characters specific for both the organisms interacting in each association.

- The phenotype is the final result of the interaction between gene pairs.

- Because there are specialised forms in many parasites, reference will be made to the host in order to designate a specific case. Besides, we have to consider the possibility of the existence of corresponding genes in intermediate host: parasite associations.

- Similarly, because there are different parasites which may be associated with a given host, reference will be made to the parasite.

- The locus and the allele (if known) need to be specified.

- The interaction of corresponding genes of two organisms in a parasitic system is frequently observed at the level of specialized form of the parasite and at the level of genus of the host.

- For many parasites there are no common names.

- Names of diseases are inadequate to represent genes or phenotypes and some of them are common for different kinds of associations.

- Taxonomic names of associated organisms are universally known.

- Symbols for the taxonomic names of the host and the parasite may be used.

- When we are dealing with a specific system already mentioned in the text concerned representations may be abbreviated, using only the first part of them. So, in this case only either "Pmn" or "Hmn" may be used.

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YELLOW RUST IN DENMARK, 1973-4

BY OLE BAGGER

State Plant Pathology Institute, Lyngby

In 1972 yellow rust (*Puccinia striiformis* West.) was epiphytotic on winter wheat in Denmark. This attack was described by Hermansen & Stapel (1973a, b). In 1973 yellow rust was also very widespread in Denmark and attacks were found in almost all winter wheat fields all over the country.

The attacks in 1973 were judged stronger than those in 1972 according to the reports from the monthly survey (Månedsoversigt over Plantesygdomme) covering plant diseases for June 1972 and 73 (Table 1).

Table 1. Incidence of yellow rust in Denmark in 1972 and 1973

	Number of reports (each report covers a certain area)	Per cent of the reported areas with: No attacks	Rare attacks	of which stronger	General widespread	of which stronger
1972	92	20	30	12	50	13
1973	88	5	14	11	81	60

After the widespread attacks in summer 1972 the development of the yellow rust was followed very closely during the autumn. Due to very dry weather in Autust and September very few volunteer plants were found in harvested winter wheat fields and thus inoculum sources appeared to be absent or extremely rare. Winter wheat fields were examined extensively throughout the autumn and mild period of the winter.

Not until December 19th 1972 was yellow rust observed in winter wheat fields. These were particularly in Lolland-Falster but attacks were also observed in other, mainly Southern parts of the country. Attacks were particularly noted in the earliest sown winter wheat fields. However, the night frosts which set in early in January blurred the symptoms, which, however, became evident again towards the end of March.

In April, attacks of yellow rust could be observed in several winter wheat fields all over the country. In the latter half of May and the first half of June, the attacks spread vigorously in the winter wheat fields sown with the varieties Kranich and Cato. Probably due to the dry weather the attacks showed no significant spread in the wheat crop after heading.

The attacks in 1973 were judged to be more severe and more widespread than in 1972, but the drought during the late summer limited the spread significantly, so that the yield for winter wheat for the country averaged 46 hkg/ha (1 hkg = 100 kg) in spite of the severe attacks earlier in the year. It is supposed that yellow rust reduced the yield of winter wheat by some 3 to 4 hkg per hectare.

The varieties of winter wheat grown in Denmark in the years 1966-1973 in per cent is shown in Table 2 (Ullerup, 1974).

Table 2. Areas of winter wheat varieties in Denmark, 1966-73 (as % total area)

Varieties	Year 1966	1968	1970	1971	1972	1973
Starke	98	91	12	2	-	1
Kranich	-	-	55	86	90	89
Cato	-	1	32	11	9	7
Other varieties	2	8	1	1	1	3
Area with winter wheat, 1000 ha	74	72	80	87	99	91

In 1974 other varieties, e.g. the Swedish variety Starke were also cultivated.

In 1974 the winter wheat area in Denmark is estimated to have been reduced by approximately 20 per cent and accordingly the area now makes up approximately 75,000 hectares out of a total area of cereals of approximately 1.8 million hectares.

The variety Starke, which in the late sixties was predominant, is in 1974 judged to cover about 50% of the wheat area, whereas another Swedish variety Solid covers about 20% and other varieties approximately 5%. Kranich and Cato are only judged to cover approximately 25% of the total wheat area in 1974. (See also Tables 3 and 4).

Table 3. Grain yield and Yellow rust incidence of some varieties grown in Denmark 1973. (Thøgersen & Ullerup, 1974)

	Grain yield in 39 trials	Yellow rust (1-10 scale)
Starke	100 (53.7 hkg/ha)	1.3
Starke II	98	1.4
Solid	108	1.4
Holme	107	2.0
Kranich	100	4.6
Cato	102	4.6

Table 4. Grain yield in winter wheat (relative figures) for Denmark in the last 5 years (Thøgersen & Ullerup, 1974)

	1969	1970	1971	1972	1973
Starke	100	100	100	100	100
Kranich	115	116	108	107	100
Cato	114	113	110	105	102
Holme	107	106	105	108	107

Contrary to what was the case in the aumumn of 1972 when it was practically impossible to find volunteer plants in the winter wheat fields, a great number of volunteer plants were found in the autumn of 1973. Towards the end of September, yellow rust was found in volunteer wheat plants on several localities in Lolland-Falster. Further, in October-November, yellow rust was observed in volunteer plants in the other parts of the country. In the newly sown wheat fields, no attacks of yellow rust were observed in the autumn of 1973. Most fields were sown at a relatively late time, namely, in October, due to the drought. Thus, most winter wheat fields had very small plants at the end of 1973.

In Februrary 1974 yellow rust was observed in a winter wheat field in Falster. The field adjoins a seed fields in which many volunteer plants with attacks of yellow rust were found. During the spring attacks in a number of fields all over the country were observed, in particular in the varieties Starke and Solid. In the seedling stage Starke and Solid are very susceptible to yellow rust.

During summer 1973 only rather weak attacks of yellow rust were observed in the spring wheat fields, mostly in fields adjoining severely attacked winter wheat fields.

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SPORULATION OF PUCCINIA STRIIFORMIS ON NINE WINTER WHEAT VARIETIES AT DIFFERENT GROWTH STAGES

BY G.E. RUSSELL & L.R.L. HUDSON

Plant Breeding Institute, Trumpington, Cambridge

As part of a study of the nature of "stable" resistance to yellow rust (*Puccinia striiformis* West.), the expression of resistance in different wheat varieties has been studied at several growth stages. This paper presents the results of glasshouse experiments in which the amount of sporulation on leaves of nine winter wheat varieties was assessed at seven growth stages, ranging from seedling to adult plant, after inoculation with a mixture of uredospores of four races of *P. striiformis*.

MATERIALS AND METHODS

The varieties of wheat which were used in the experiments are listed below, together with the corresponding abbreviations used in Fig. 1:-

Nord Desprez (ND) - susceptible control
Wilma (W)
Holdfast (H)
Cappelle-Desprez (CD)
West Desprez (WD)
Little Joss (LJ)
Yeoman (Y)
Browick (B)
Juliana (J)

A mixture of four races of *P. striiformis*, namely 104 E 9(3/55 Opal), 104 E 137 (3/55D), 41 E 136 (58C) and 40 E 8 (2B), to which these varieties are susceptible as seedlings, was used throughout the experiments.

For seedling tests, plants were grown in 8 cm diameter pots containing sterilised potting compost, eight to a pot, in a spore-proofed glasshouse. When the first leaf had fully expanded, the pots were placed in an inoculation chamber into which uredospores of the four races were blown. The inoculated plants were kept in the chamber for at least 30 h in conditions of high humidity before being returned to the glasshouse bench.

Where plants were to be inoculated at later growth stages, seed was sown in 3 cm diameter peat pots containing potting compost. After germination the pots were placed in a cold room at 5 - 8°C with low light intensity and short days for at least 6 weeks to vernalise the plants. They were then potted on into 13 cm diameter pots and placed in a spore-proofed glasshouse until the appropriate growth stage was reached. Experiments were carried out with previously rust-free plants at Growth Stages 1, 3, 4, 5, 6, 8 and 10.5 on the Feekes Scale (Large, 1954), which are equivalent to Stages 11, 21, 30, 30, 31, 37 and 59 on the Zadoks Scale (Zadoks, Chang & Konzak, 1974). Each experiment consisted of five or six randomised blocks with one plant per plot. Older plants were inoculated in a spore-settling tower before being placed in plastic bags for incubation periods of about 30 h.

The amount of sporulation on each plant was assessed by eye after 10-14 days with seedlings and 21-25 days with adult plants. A scale of 0 for no sporulation to 5 for very profuse sporulation was used to compare sporulation on different varieties at the same growth stage.

RESULTS AND DISCUSSION

Mean sporulation scores for the nine varieties, adjusted so that Nord Desprez has a score of 4.0 at each growth stage, are given in Fig. 1. For the sake of clarity, Fig. 1 is presented in two parts each giving the scores of four varieties and Nord Desprez; comparisons are equally valid, however, between any of the nine varieties at a particular growth stage.

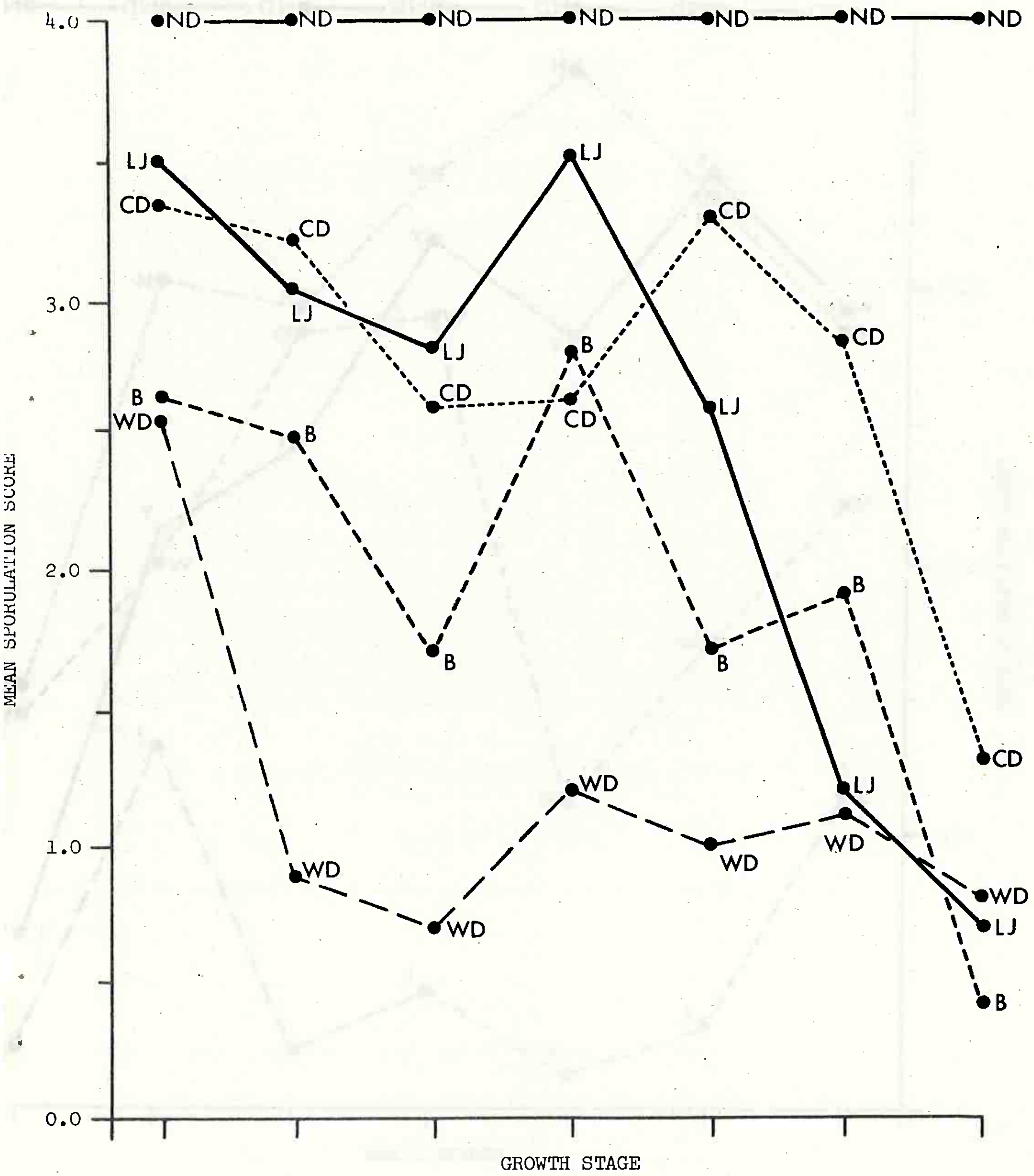
Differences between sporulation scores were highly significant ($P<0.001$) at all growth stages tested. Standard errors of the difference between two means (S.E.) and least significant differences (L.S.D.) between scores of varieties and the susceptible control, Nord Desprez, are given in Figs. 1a and 1b.

Sporulation was low in Juliana at each of the seven growth stages and in West Desprez after the seedling stage. It was consistently high in Nord Desprez and of intermediate intensity in Wilma. In the other varieties sporulation scores, in relation to those of Nord Desprez, decreased progressively with increasing age. This was particularly marked in Little Joss and Yeoman which were among the most susceptible varieties before stem elongation and the most resistant after ear emergence.

These results show clearly that the relative susceptibility of certain varieties to yellow rust varies greatly at different growth stages; in other varieties it does not. In several varieties resistance was manifested only after the onset of stem elongation. This may relate to vernalisation which can greatly affect susceptibility to yellow rust in certain winter wheat varieties (Russell & Hudson, 1973). It follows, therefore, that the results of seedling tests will not necessarily be a good guide to the level of resistance shown by older plants.

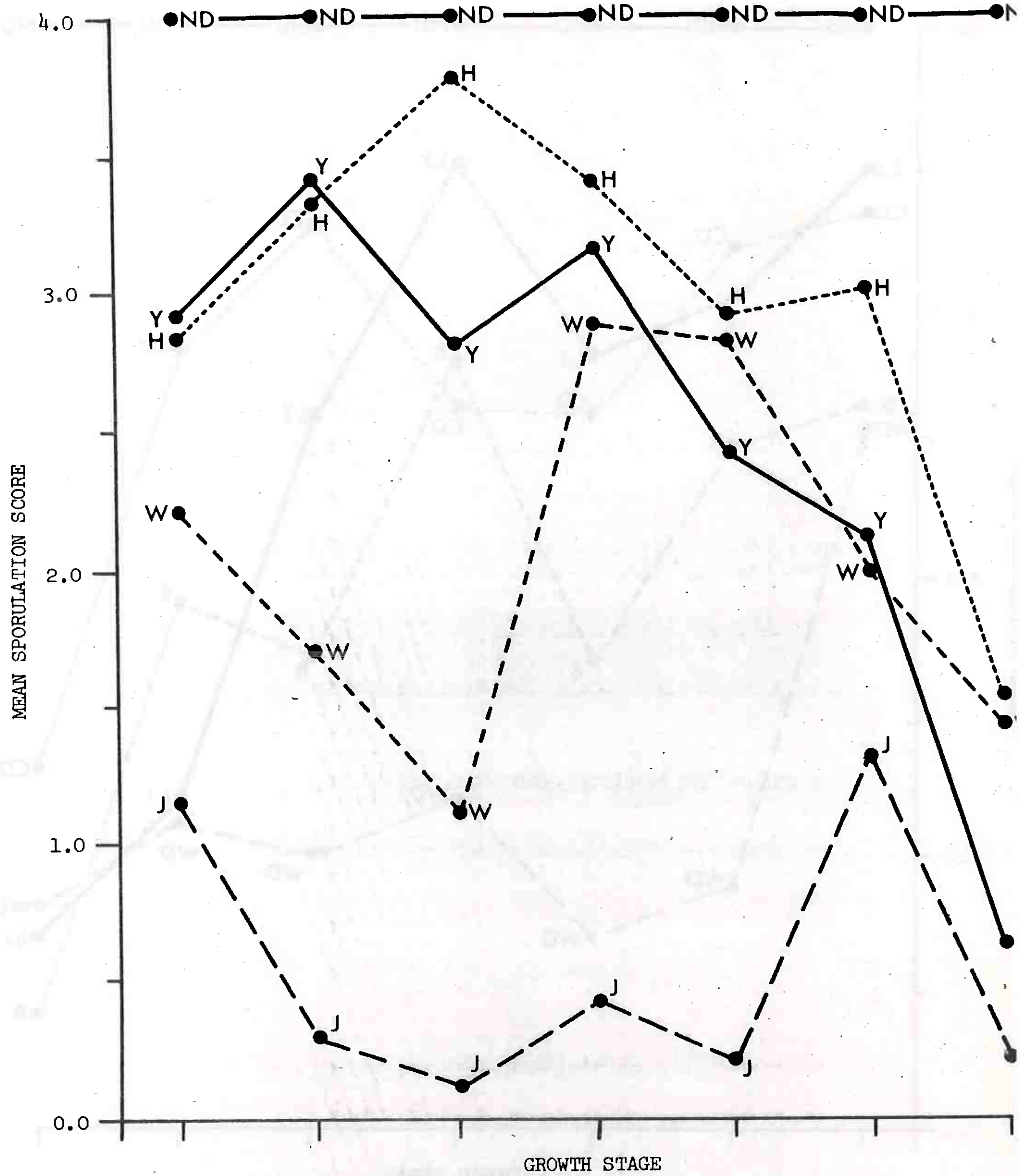
Of the varieties tested, Little Joss, Yeoman and Holdfast have shown a fairly high level of "stable" adult plant resistance to yellow rust in the field (Dillon Weston, 1944; Manners, 1950; Batts, 1957; Doling, 1967). Cappelle-Desprez has shown stability but at a lower level of resistance. With none of these varieties has there apparently been any serious problems due to changes in occurrence of physiologic races of P. striiformis. Conversely, Nord Desprez and Wilma were severely attacked by certain physiologic races when grown commercially and their resistance is obviously highly race specific. The reaction of Juliana to yellow rust can be extremely variable (Manners, 1950) and the stability of its resistance under field conditions is not known.

In these experiments the varieties which are known to have the highest level of "stable" adult plant resistance were those which were very susceptible at the seedling stage but very resistant as adult plants to the races used.



(FEEKES)	1	3	4	5	6	8	10.5
(ZADOKS)	11	21	30	30	31	37	59
S.E.	±0.3	±0.3	±0.3	±0.4	±0.7	±0.4	±0.8
L.S.D. (P<0.05)	0.7	0.7	0.7	0.8	1.5	0.9	1.6

Fig. 1a. Sporulation scores for five varieties at seven growth stages (please see text for abbreviations).



(FEEKES)	1	3	4	5	6	8	[illegible]
(ZADOKS)	11	21	30	30	31	37	[illegible]
S.E.	±0.3	±0.3	±0.3	±0.4	±0.7	±0.4	[illegible]
L.S.D. (P<0.05)	0.7	0.7	0.7	0.8	1.5	0.9	[illegible]

Fig. 1b. Sporulation scores for four other varieties and Nord Desprez at seven growth stages.

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MARIS HUNTSMAN AND YELLOW RUST

During the last two weeks of June, 1974, evidence was received that in North-East England the winter wheat variety Maris Huntsman was reacting more severely to yellow rust than had been observed previously. This may mean that a genetic variant of the rust has developed that will attack Maris Huntsman more seriously than known races and variants. At the time of writing, results of tests on Maris Huntsman and differential hosts are not available, so a full understanding of the situation is not yet possible. It appears unlikely that in 1974 yellow rust on Maris Huntsman will have much effect on U.K. wheat production (in 1974 this variety occupies some 30-40% of the wheat acreage in Britain), but farmers with affected crops have been advised that spraying with an appropriate fungicide may be necessary, and that in future seasons, Maris Huntsman may be less resistant to yellow rust than has been the case hitherto.

(Information received from the Plant Breeding Institute, Cambridge, and published with the permission of the Institute).

EUROPEAN AND MEDITERRANEAN CEREAL RUSTS FOUNDATION

FINANCIAL REPORTS

Income and expenditure account, 1 January 1973 to 31 December 1973

RECEIPTS			PAYMENTS		
Subscriptions, current year	f.	745.55	Bank charges	f.	98.23
Subscription 1974	"	20.-	Bank (erroneous booking)	"	191.31
Bank interest	"	23.36	Administration	"	1067.40
Reprints	"	48.33	Cereal Rusts Bulletin	"	1189.95
Excess of exp. over income	"	1709.65			
	f.	2546.89		f.	2546.89

Balance sheet as at 31 December 1973

CREDIT			DEBIT			
Funds at bank	f.	3572.27	Foundation costs		f.	171.00
			Capital 31.12.72:	f.4919.61		
			Reservation (erroneous booking):	+ f. 191.31		
				f.5110.92		
			Net exp. -	" 1709.65	"	3401.27
	f.	3572.27			f.	3572.27

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