Inheritance of resistance to Albugo candida in Brassica napus.

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Introduction

White rust caused by the fungus Albugo candida (Pers. ex Chev.) Kuntze. is a common disease of many cruciferous species. A degree of physiological specialization of isolates of the pathogen, an obligate parasite, has been found and the method of classifying the races of this fungus established by Pound and Williams (1963) based on host specificity is generally accepted.

Summer rape (B. napus) cultivars grown in Canada are highly resistant to Albugo candida. However several strains of B. napus obtained from the People's Republic of China are susceptible to white rust. Because of the lack of information regarding the genetics of white rust resistance in rape, this study was undertaken to provide information on the inheritance of the host reaction to white rust in rape.

Materials and Methods

The experiment was conducted in growth chambers during 1981 and 1982. The Canadian cultivar, Regent, is resistant to white rust and was used as the resistant parent in test crosses. Two Chinese lines, Green Cup Leaf (GCL) and 2282-9 were chosen because of their susceptibility to white rust, both in the field and when artificially inoculated in growth chambers. The reactions of GCL and 2282-9 to white rust are somewhat different. Pustules occurring on GCL were of small size usually surrounded by chlorotic haloes and seldom merged to form patches. Pustules on 2282-9 frequently coalesced to form patches and chlorosis occurred less frequently. However these reactions were not very distinct, since the two reactions could appear on different leaves or even on the same leaf of a plant in both strains.

As GCL and 2282-9 are winter forms of rape, these cultivars were planted one month earlier than Regent to ensure that flowering would occur simultaneously. At the 3-4 leaf stage the plants were vernalised at 4°C for four weeks and then returned to the greenhouse. Crosses were made to obtain all combinations and reciprocal combinations of Regent, GCL and 2282-9. Five plants were used for each cross and its reciprocal. Several F1 plants of each cross were backcrossed to their susceptible parents, and F1 plants were self-pollinated to obtain seed for an F2 generation.

The F1, F2, backcross progenies and the parent lines were tested for white rust resistance at the second leaf stage. Plants of the susceptible turnip rape Torch were randomly included in the tests to ensure that inoculation technique was satisfactory.

The inoculum was zoosporangia of A. candida collected from Torch and Span (B. campestris) grown in the field in the summers of 1981 and 1982. The zoosporangia were stored in gelatin capsules in a freezer at a temperature below -10°C. After inoculation, plants were incubated in a misting chamber for 3 days at 20°C and 18h photoperiod before returning them to a growth chamber.

Results

F1 Reactions

The reaction of the F1 plants from crosses and reciprocal crosses between GCL, 2282-9 and Regent to white rust was the same as that of the resistant parent, Regent. Thus the resistance carried by Regent is dominant and controlled by the nuclear genes. All F1 progenies from the GCL x 2282-9 cross and its reciprocal were susceptible.

Because of the similarity of reaction of GCL and 2282-9, it was not possible to classify F1 reactions in relation to that of the parents. However no resistant F1 plants were observed in the progeny of the cross between the two susceptible cultivars.

F2 Reactions: 1. 2282-9 x Regent

The F2 progeny from the cross 2282-9 x Regent cross segregated for white rust reaction in a ratio of 15 resistant to 1 susceptible (Table 1) and the progeny from the backcross (2282-9 x Regent) x 2282-9 segregated in a ratio of 3 resistant to 1 susceptible (Table 2). These data indicate that two loci with dominance for each allele condition resistance in this cross.

2. GCL x Regent

Two different segregation ratios were obtained in the F2 and backcross generations of progeny from crosses involving GCL and Regent. The 15:1 F2 ratios and the 3:1 backcross ratios were observed for the progeny of F1 plants 1 to 8 inclusive, while 63:1 F2 and 7:1 backcross ratios were obtained for progeny of F1 plants 9 to 12 inclusive (Tables 3 and 4). Progeny from crosses involving the individual plants GCL 5 and Regent 5 segregated in the manner expected when 3 gene loci are involved, while the two progeny from crosses involving the individual plants GCL 4 and Regent 4 segregated in both digenic and trigenic ratios. This suggests that Regent 4 was heterozygous at one of the three loci for white rust resistance.

3. GCL x 2282-9

All of the 770 F2 plants tested from the GCL x 2282-9 cross were susceptible to white rust.

Discussion and Conclusions

The resistance of Regent to white rust is conditioned by at least three gene loci and genes for resistance are dominant. These genes segregated independently and presence of a dominant allele at any one of the three loci results in the expression of host resistance. Homozygous recessives at the three loci lead to susceptibility. According to the proposal of Humaydan and Williams (1976), these three genes are designated Ac7-1, Ac7-2, and Ac7-3.

Rapeseed has been grown in Canada for approximately 40 years. During this period cultivars of *B. campestris* have been susceptible to white rust, while the resistance in *B. napus* has remained effective. This study provides information on the genetic basis of this resistance. The number of genes for resistance in the Canadian cultivars probably has helped to prevent the pathogen from overcoming this resistance. For this reason, plant breeders should be cautious when they use cultivars of *B. napus* from the Orient as crosses into *B. campestris* in breeding programs.

References

Humaydan, H.S. and Williams, P.H. 1976. Inheritance of seven characters in *Raphanus sativus* L., Hort. Sci. *11*:146-147.

Pound, G.S. and Williams, P.H. 1963. Biological races of *Albugo candida*. Phytopathol. *53*:1146-1149.

TABLE 1

Observed segregation and Chi-square tests for F2 data from 2282-9 (22) X Regent (RR) involving resistance (R) and susceptibility (S) to A. candida

Source of Population	F1 Plant No.[a]	Reaction R	Reaction S	Ratio	X^2	P
F2(22xRR)	1	101	2	15:1	3.26	.05-.10
	2	92	8	15:1	0.52	.30-.50
	3	100	5	15:1	0.40	.50-.70
	4	97	10	15:1	1.75	.10-.20
	5	98	9	15:1	0.85	.30-.50
	6	95	6	15:1	0.02	.70-.90
	7	100	5	15:1	0.40	.50-.70
	8	300	21	15:1	0.05	.70-.80
	9	101	10	15:1	1.44	.20-.30
Total		1084	76	15:1	8.69	
Deviation					0.18	.50-.70
Heterogeneity					8.51	.30-.50

TABLE 2

Observed segregation and Chi-square tests for backcross data from 2282-9 (22) X Regent (RR) involving resistance (R) and susceptibility (S) to A. candida

Source of Population	F1 Plant No.[a]	Reaction R	Reaction S	Ratio	X^2	P
BC(22xRR)x22	1	87	20	3:1	2.27	.10-.20
	2	78	29	3:1	0.25	.50-.70
	3	80	22	3:1	0.64	.30-.50
	4	88	26	3:1	0.29	.50-.70
	5	76	30	3:1	0.62	.30-.50
	6	77	29	3:1	0.31	.50-.70
	7	80	25	3:1	0.08	.70-.90
	8	244	75	3:1	0.38	.50-.70
	9	80	25	3:1	0.08	.70-.90
Total		890	281	3:1	4.92	
Deviation					0.63	.30-.50
Heterogeneity					4.29	.70-.90

[a]The F1 plant numbers for F2 and backcross populations correspond to each other, indicating that both populations were derived from the same F1 parent.

TABLE 3

Observed segregation and Chi-square tests for F2 data from GCL X Regent (RR) involving resistance (R) and susceptibility (S) to A. candida

Source of Population	F1 Plant No.[a]	Reaction R	Reaction S	Ratio	X^2	P
F2(GCL-1xRR-1)	1	80	9	15:1	2.27	.10-.20
	2	91	3	15:1	1.50	.20-.30
	3	74	7	15:1	0.79	.30-.50
	4	96	4	15:1	0.86	.30-.50
	5	96	5	15:1	0.39	.50-.70
	6	92	10	15:1	2.20	.10-.20
F2(GCL-4xRR-4)	7	93	3	15:1	1.60	.20-.30
	8	98	7	15:1	0.03	.70-.90
Total		720	48	15:1	9.54	
Deviation					0.00	.95-1.0
Heterogeneity					9.54	.20-.30
F2(GCL-4xRR-4)	9	91	1	63:1	0.14	.70-.90
	10	103	2	63:1	0.08	.70-.90
F2(GCL-5xRR-5)	11	153	2	63:1	0.08	.70-.90
	12	160	5	63:1	2.31	.10-.20
Total		507	10	63:1	2.61	
Deviation					0.46	.30-.40
Heterogeneity					2.15	.50-.70

[a]The F1 plant numbers in F2 and backcross populations correspond to each other, indicating that both populations were derived from the same F1 parent.

TABLE 4

Observed segregation and Chi square tests for backcross data from GCL X Regent (RR) involving resistance (R) and susceptibility (S) to A. candida

Source of Population	F1 Plant No.[a]	Reaction R	Reaction S	Ratio	X^2	P
BC(GCL-1xRR-1)xGCL	1	35	14	3:1	0.33	.50-.70
	2	80	28	3:1	0.05	.70-.90
	3	73	21	3:1	0.36	.50-.70
	4	75	29	3:1	0.46	.30-.50
	5	60	22	3:1	0.15	.70-.90
	6	83	20	3:1	1.71	.10-.20
BC(GCL-4xRR-4)xGCL	7	85	18	3:1	3.11	.05-.10
	8	81	23	3:1	0.46	.30-.50
Total		572	175	3:1	6.63	
Deviation					0.99	.30-.50
Heterogeneity					5.64	.50-.70
BC(GCL-4xRR-4)xGCL	9	92	10	7:1	0.68	.30-.50
	10	91	13	7:1	0.00	.95-1.0
BC(GCL-5xRR-5)xGCL	11	89	18	7:1	1.83	.10-.20
	12	95	16	7:1	0.37	.50-.70
Total		367	57	7:1	2.88	
Deviation					0.35	.50-.70
Heterogeneity					2.53	.30-.50

[a]The F1 plant numbers in F2 and backcross populations correspond to each other, indicating that both populations were derived from the same F1 parent.