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RACE AND RESISTANCE STUDIES ON TWO ITALIAN POPULATIONS OF *HETERODERA AVENAE*

by
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Summary. Twenty five near-isogenic lines of wheat, oat and barley were tested for their resistance to two Italian populations of *Heterodera avenae* in a glasshouse experiment. All of the lines were resistant to both populations, which were identified as pathotype *Ha51* (from Basilicata) and *Ha41* (from Sardinia), with the possibility that the latter might be one of the Spanish pathotypes *Ha71* or *Ha 81*.

The development of resistant cultivars is the most promising control method against the cereal cyst nematode *Heterodera avenae* Woll., for which the use of chemicals is economically unacceptable. Different sources of resistance, associated with single dominant genes, are present in cereals (Andersen and Andersen, 1970), but breeding is complicated because of the presence of different pathotypes of *H. avenae*, characterized by different levels of virulence.

This paper reports the screening of 5 near-isogenic lines of wheat, 7 of oat, and 13 of barley (all with some resistance to *H. avenae*) against two Italian populations of the cyst nematode. The two populations were tested on some of the discriminating cereal cultivars of the International Test Collection to identify the pathotype (s) to which they belong.

Materials and methods

Soil naturally infested by *H. avenae* was collected from a field at Genzano (province of Potenza, Basilicata) and a field at Guasila (province of Cagliari, Sardinia) in both of which durum wheat (*Triticum durum* L.) had been cultivated for many years. The initial nematode population density (27 and 33 eggs/g soil, respectively) was adjusted to 7 eggs/g soil, which is considered to be above the tolerance limit of wheat to *H. avenae* (Greco and Brandonisio, 1987), by adding appropriate amounts of sterilized sandy soil.

The 25 near-isogenic lines were: 5 of durum wheat, 7 of oat (*Avena sativa* L.) and 13 of barley (*Hordeum vulgare* L.) (Table I).

Pots (12 cm diam) were filled with infested soil and each sown with four seeds of each cereal. There were four replicates for each line or test cultivar in each of the two soils. The pots were arranged in a randomized block design on benches in a glasshouse at 17±2 °C. Irrigation, fertilization, disease and pest control measures were applied as required. Plants were cut at the soil level three months after sowing and cysts were extracted from a 200 g soil sample with the Fenwick can. Cysts were then crushed (Seinhorst and Den Ouden, 1966) and eggs and juveniles were counted to calculate the numbers per g of soil.

The lines and the cultivars tested were considered resistant if the final nematode density in the soil was lower than the initial, i.e. if the nematode did not reproduce. Numbers of eggs of each nematode population on different lines were compared by analysis of variance and Duncan's multiple range test, while for each line the comparison between the two populations was made by the Student's *t* test.

In the pathotype identification test reproduction of the two nematode populations was challenged on 7 cultivars of barley (Dalmatische, Emir, Harlan 43, Herta, Morocco, Ortolan and Varde), 2 cultivars of oat (Silva and Sun II) and one cultivar of rye (*Secale cereale* L.) (Petkus Spring), belonging to the International Test Collection for the identification of the pathotypes of *H. avenae* (Nielsen, 1972). The choice was limited to these nine cultivars because of their immediate availability at the Istituto del Germoplasma-C.N.R., Bari, Italy.

Results

The final nematode density of the population from Basilicata on all the 25 lines was lower than the initial

TABLE I - *Final density (eggs and juveniles/g soil) of two Italian populations of* Heterodera avenae *on 25 near-isogenic lines (Pf = final population; Pi = initial population of the nematode in the soil).*

Line code	Lines	Nematode population				*t* test between populations
		Basilicata		Sardinia		
		Pf	*t* test of *Pf* vs *Pi*	*Pf*	*t* test of *Pf* vs *Pi*	
Wheat						
IGV 1-2824	Prins (receptor)	0.9 a	**	3.1 a	–	–
IGV 1-701	Loros x Prins	2.5 a	*	1.9 a	**	–
IGV 1-702	Australia 10894 x Prins	1;9 a	**	1.5 a	**	–
IGV 1-703	Iskamish x Prins	1.8 a	**	2.5 a	**	–
IGV 1-704	Red Egyptian X Prins	1.7 a	**	1.5 a	**	–
Oat						
IGV 5-1050	Sun II (receptor)	2.8 a	**	4.3 a A	*	–
IGV 5-301	A. sterilis GHb x Sun II	2.5 a	**	1.8 b B	**	–
IGV 5-302	A. sterilis Rouda x Sun II	2.4 a	*	2.0 b B	**	–
IGV 5-303	US 1625-4575 x Sun II	1.7 a	**	1.7 b B	**	–
IGV 5-304	Grise de Houdan x Sun II	2.9 a	*	2.9 ab AB	*	–
IGV 5-305	CI 2095, Calcutta x Sun II	2.9 a	–	3.2 ab AB	**	–
IGV 5-306	Pusa Hybrid G x Sun II	3.9 a	*	2.6 b AB	*	–
Barley						
IGV 3-2027	Ingrid (receptor)	1.6 bc AB	**	5.0 a A	–	–
IGV 3-401	Barley 191 x Ingrid	1.1 bc AB	**	4.6 ab AB	–	–
IGV 3-402	Morocco x Ingrid	2.0 abc AB	*	4.7 a A	–	*
IGV 3-405	Ogalitsee x Ingrid	1.2 bc AB	**	2.6 abc ABC	**	–
IGV 3-406	Kron x Ingrid	3.6 a A	**	5.0 a A	–	–
IGV 3-408	Goldfoil x Ingrid	2.3 abc AB	**	1.0 c C	**	–
IGV 3-409	Osiris x Ingrid	3.0 ab AB	*	3.4 abc ABC	*	–
IGV 3-410	Drost x Ingrid	1.5 bc AB	**	2.0 bc ABC	**	–
IGV 3-413	CI 4226 x Ingrid	2.3 abc AB	**	3.6 abc ABC	**	*
IGV 3-414	Ariana x Ingrid	0.6 c B	**	2.6 abc ABC	**	–
IGV 3-415	CI 3725 x Ingrid	2.4 abc AB	*	1.2 c BC	**	–
IGV 3-416	Martin 403-2 x Ingrid	2.5 abc AB	*	2.8 abc ABC	*	–
IGV 3-417	Bajo-Aragon 1-1 x Ingrid	2.7 abc AB	*	2.9 abc ABC	*	–

Data flanked in any column by the same letters are not statistically different according to Duncan's multiple range test (small letters for P = 0.05; capital letters for P = 0.01).
Statistically different according to Student's *t* test: * for P = 0.05; ** = for P = 0.01.

population and the reduction was always statistically significant, except on the oat line IGV 5-305 (Table I). No significant difference was found in the reproduction of *H. avenae* on the lines of wheat or oat. In the pots sown with the barley line IGV 3-414 the final nematode density was significantly (P = 0.01) lower than on the line IGV 3-406, but there was no statistical difference among the other barley lines.

The population from Sardinia did not reproduce on any of the tested lines, with a maximum value of final density of 5 eggs and juveniles/g soil for the barley receptor Ingrid and line IGV 3-406. The comparison with the values of the initial population density showed that difference was significantly lower for the wheat and barley receptors and for the barley lines IGV 3-401, 3-402 and 3-406. In oat the receptor gave a final population significantly (P = 0.01) higher than the lines IGV 5-301, 5-302 and 5-303. Among the barley lines, for IGV 3-408 and IGV 3-415 the nematode population reduction was greater than on the receptor and on the lines IGV 3-402 and IGV 3-406. No differences were found among the lines of wheat.

The comparison of the behaviour of the two nematode populations on each line indicated a significant (P = 0.05) difference only for the lines IGV 3-402 and 3-413 of barley.

The reaction of the 9 test-cultivars to the two Italian populations of *H. avenae* is reported in Table II. The population from Basilicata did not reproduce on any of the tested cultivars, with a consistently significant (P = 0.01) reduction of nematode density. Barley cultivars Dalmatische, Herta, Emir and Varde were susceptible to the population from Sardinia, as the final nematode density was higher than the initial one. However, the population reduction was not statistically significant for cv. Dalmatische. The oats Silva and Sun II showed resistance while the rye Petkus Spring appeared to be susceptible.

These results indicated that the two populations belong to different pathotypes, according to the Andersen and Andersen's classification (1982). The population from Basilicata is similar to pathotype *Ha51* or *Ha31*: pathotype *Ha51* was found by Kort *et al.* (1964) in The Netherlands, sporadically in Germany by Lücke (1976) and in Norway by Stoen (1971), while the pathotype *Ha31* shows a reaction pattern typical of Indian populations (Mathur *et al.*, 1974; Swarup *et al.*, 1979). Therefore the population from Basilicata could probably be considered as the European pathotype *Ha51*.

The Sardinia population showed a behaviour similar to that of the pathotype *Ha41* or *Ha21*, and a complete coincidence with that of the Spanish pathotypes *Ha71* or *Ha81* (Sanchez and Zancada, 1987). Pathotype *Ha41* corresponds to the *Fr1* found by Rivoal (1977) in French populations, while the *Ha21* was reported only in Northern

TABLE II - *Reaction of cultivars from the International test collection to pathotypes of* Heterodera avenae *(from Andersen and Andersen, 1982) to two Italian populations of the nematode.*

Cultivars tested	Pathotypes										Pathotypes					
	Group 1						Group 2	Group 3			Basilicata			Sardinia		
	Ia11	Ha21	Ha31	Ha41	Ha51	Ha61	Ha12	Ha13	Ha23	Ha33	*Pf*	*t* test of *Pf* vs *Pi*	reaction	*Pf*	*t* test of *Pf* vs *Pi*	reaction
Barley																
Dalmatische	R	–	–	S	–	R	S	S	R	S	2.6	**	R	8.2	–	S
Emir	S	S	–	S	–	S	S	S	S	S	3.0	**	R	10.9	*	S
Harlan 43	R	–	–	–	–	–	R	–	R	S	2.5	**	R	1.5	**	R
Herta	S	S	R	–	R	–	S	S	–	–	2.6	**	R	11.0	*	S
Morocco	R	R	R	R	R	R	R	R	R	R	1.8	**	R	1.2	**	R
Ortolan	R	R	R	R	R	R	S	S	S	S	1.6	**	R	1.8	**	R
Varde	S	S	–	S	–	S	S	S	S	S	1.8	**	R	11.1	**	S
Oats																
Silva	R	–	–	R	–	R	R	R	S	S	2.4	**	R	1.9	**	R
Sun II	S	R	R	R	R	S	S	S	S	S	2.4	**	R	2.0	**	R
Rye																
Petkus Spring	-	-	-	-	-	-	–	-	-	-	1.5	**	R	12.9	*	S

S = susceptible; R = resistant; - = no observation.
Statistically different according to Student's *t* test: * for P = 0.05; ** for P = 0.01

Europe (Kort *et al.*, 1964; Lücke, 1976). The similar environmental conditions, the closer proximity of cropping areas and the history itself of the island suggest that the population from Sardinia could be attributable to pathotype *Ha41* or to the Spanish pathotypes *Ha71* or *Ha81*.

Discussion

All the near-isogenic lines tested in the first experiment were resistant to both the *H. avenae* populations, with no particularly significant difference between them. The test with the nematode population from Basilicata must, however, take into account that under field conditions this population seems to be strongly suppressed by parasitic fungi; so the experiment should be repeated in steamed or autoclaved soil to verify if the lack of nematode reproduction was due to the resistance of lines or to the fungal parasitism. Interference of fungi parasitic to nematode eggs may have affected also the results obtained with this population in the pathotype identification test.

The attribution of the two *H. avenae* populations to different pathotypes could also explain their different impact on the cereal crop as the Sardinia population appears to be more virulent and causes greater yield losses than that from Basilicata. However, this should be considered as a preliminary study and its results need confirmation using the whole International Collection of test cultivars, and populations of the nematode free of egg parasites.

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