REACTION OF WHEAT GENOTYPES TO A POPULATION OF *HETERODERA AVENAE* FROM PUNJAB, INDIA

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Summary. Wheat varieties/lines from diverse sources were evaluated for their reaction to a population of the cereal cyst nematode (CCN), *Heterodera avenae* (pathotype Ha 41), from Ludhiana, Punjab, India. Of the 38 tested varieties/lines, eight had been previously rated as either resistant or moderately resistant to populations of CCN other than from Ludhiana, nine were resistant to *Tilletia indica* (Karnal bunt), six were derived from the BC_3 population of the cross KBRL22/3*PBW343, and fifteen were synthetic lines derived from *Triticum tauschi* × *Triticum durum*. Of the varieties earlier reported resistant to CCN, two (AUS 15854 and AUS 15895) were found resistant to the Ludhiana population of the CCN, whereas AUS 15807 was only moderately resistant. Only one of the Karnal bunt resistant variety, KBRL 13, was resistant while KBRL 10, KBRL 22, CMH 77.308 and H 567.71 were moderately resistant to CCN. Of the lines from the cross KBRL22/3*PBW343, three were moderately resistant. Amongst the fifteen synthetic lines, two (Nos 19-1 and 63) were found resistant to CCN (pathotype Ha 41), Karnal bunt and leaf and stripe rusts in Ludhiana, Punjab.

Key words: Cereal cyst nematode, resistance, *Triticum durum*, *T. tauschi*.

The cereal cyst nematode (CCN), *Heterodera avenae* Woll. is an important nematode pest of oat (*Avena sativa* L.), wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.), especially in sandy soils. Losses to wheat of up to 100% have been reported in India (Van Berkum and Seshadri, 1970). The nematode can be managed effectively using CCN resistant varieties. Resistance in wheat to CCN has been reported from CIMMYT (Centro Internacional de Mejoramiento de Maíz y Trigo = International Maize and Wheat Improvement Center), Mexico, Australia and France but only a few varieties with CCN resistance are grown commercially (Rivoal and Cook, 1993; Bekal *et al.*, 1998; Nicol *et al.*, 2001). From India, resistance against CCN has been reported in a few varieties only and one has been recommended for cultivation (Bhatti and Dahiya, 1992; Sharma and Sharma, 2000; Anonymous, 2003). As *H. avenae* has different biotypes and the Ludhiana population of the nematode is different (Ha 41) to those from Haryana, Delhi (Ha 21) and Rajasthan, where population Ha 21 is prevalent, the bread wheat varieties that are resistant to populations of CCN from other states may be susceptible to the Ludhiana population (Anonymous 2003; Bishnoi *et al.*, 2004). In Punjab, the predominant variety, PBW 343, is susceptible to CCN, Karnal bunt (*Tilletia indica* Mitra), leaf rust (*Puccinia triticina* Ericks) and stripe rust (*Puccinia striiformis* Westend). Hence, it is vital to identify appropriate resistant varieties to the local nematode population.

MATERIALS AND METHODS

Plant material. One set of test plants consisted of eight wheat varieties reported as resistant/moderately resistant to other CCN populations of pathotype Ha 21 (Bishnoi *et al.*, 2004), nine Karnal bunt resistant stocks and six lines derived from the BC_3 population of a backcross, KBRL22/3*PBW343 (Sharma *et al.*, 2002, 2004). All the lines were evaluated for their reaction to the CCN population from Ludhiana (pathotype Ha 41) (Swarup *et al.*, 1979, Bishnoi *et al.*, 2004). The variety PBW 343 was used as a susceptible check.

Another set included fifteen synthetic wheat lines derived from *Triticum tauschi* Coss × *Triticum durum* Desf., obtained from CIMMYT, Mexico, which were evaluated for their response to CCN and to three other economically important diseases (Karnal bunt, stripe rust and leaf rust) in the Punjab region. The varieties, PBW 343, WH 542 and WL 711 were used as susceptible controls for CCN, Karnal bunt and the rusts, respectively.

Screening. Three seeds of each of the different varieties/lines were sown in 12.5 cm diameter and 11 cm deep pots, containing 1000 cm^3 sandy loam soil infested with two cysts of the nematode/250 cm^3 (averaging 250 eggs/cyst), in December 2004, 2005 and 2006. Nematode inoculum (cysts) was obtained from a pure culture of CCN raised from a single cyst of the Ludhiana population. Pots were thinned to one plant per pot after germination. The screening was carried out by holding the pots under field conditions in a randomized block design comprising three replicates. The minimum temperature during the experiment ranged between 1.8 and 12.4 °C and the maximum between 16.7 and 23 °C. The plants in the pots were irrigated as and when required to maintain proper growth of the plants. The cysts from

Table I. Scale suggested by the All India Coordinated Wheat and Barley Improvement Project to rate the response of wheat genotypes to *Heterodera avenae*.

Rating	Cysts per plant	Host response
1	0.0	Highly Resistant (HR)
2	0.1-4	Resistant (R)
3	4.1-9	Moderately Resistant (MR)
4	9.1-20	Susceptible (S)
5	>20	Highly Susceptible (HS)

the soil of each pot were extracted 75 days after sowing following standard Cobb's decanting and sieving technique in March 2005, 2006 and 2007. The roots were washed free of soil, the cysts were collected on a 60-mesh sieve (pore size of 250 µm) and the final population (number of white cysts/plant) was recorded. The responses of the lines and varieties to the nematode were rated according to the scale suggested by the All India Coordinated Wheat and Barley Improvement Project (Table I). Statistical analyses based both on year-wise and pooled data were carried out.

Additional data for the different diseases under artificial epiphytotic conditions on synthetic wheat were recorded in a separate set of wheat plants grown under field conditions during 2004-2006. Every year, each wheat line/variety was grown in a one metre length of row with rows spaced 25 cm apart. Screening for Karnal bunt was done using a mixture of inoculum derived from 16 isolates representing different agro-climatic regions of Punjab (Sharma *et al.*, 1998). Ten ears of each line/variety were inoculated by a standard syringe inoculation method (Aujla *et al.*, 1982). Adequate humidity was maintained in the field by frequent irrigation, except when it rained. After harvesting, the severity of Karnal bunt infection was calculated based on healthy and infected grains in the inoculated ears. Lines scoring up to 5% Karnal bunt infection were rated resistant according to the standard scoring method (Sharma *et al.*, 2002). Statistical analysis of the three years of pooled data was carried out for Karnal bunt infection.

Table II. Responses of wheat lines and varieties to the Ludhiana population of *H. avenae*.

Wheat lines	Cysts/plant*				Reaction
	2004	2005	2006	Average (range)	
Resistant/moderately resistant varieties					
Raj MR-1	15.5	13.3	12.7	13.8 (11-17)	S
AUS 15854	2.3	3.00	1.0	2.1 (1-4)	R
AUS 15895	4.0	3.7	2.7	3.4 (2-5)	R
AUS 15807	8.3	5.7	4.7	6.2 (4-9)	MR
AUS 498	12.3	18.0	16.7	15.7 (12-20)	S
IK_2Light	19.3	18.7	18.0	18.7 (17-20)	S
Psathias	22.0	16.7	18.7	19.2 (16-23)	S
P-31322-1	14.3	18.3	16.0	16.2 (13-19)	S
Karnal bunt resistant varieties					
KBRL 10	10.5	11.3	10.3	10.7 (10-12)	S
KBRL 13	4.0	2.5	2.7	3.0 (2-4)	R
KBRL 22	4.5	3.7	6.0	4.7 (3-8)	MR
CMH 77.308	7.0	4.7	8.3	6.7 (4-9)	MR
H 567.71	8.5	5.5	9.0	7.7 (5-10)	MR
Aldan	11.0	15.3	10.7	12.3 (10-16)	S
HD 29	10.5	15.5	12.3	12.8 (10-17)	S
W 485	14.0	18.3	14.7	15.6 (13-20)	S
HP 1531	10.0	16.7	9.7	12.1 (9-20)	S
Karnal bunt resistant lines derived from cross KBRL22/3*PBW 343					
S. No. 11	9.0	8.3	7.7	8.3 (7-10)	MR
S. No. 18	11.0	14.0	9.3	11.4 (8-16)	S
S. No. 27	7.00	9.3	6.7	7.7 (6-10)	MR
S. No. 36	18.0	20.5	18.3	18.9 (14-21)	S
S. No. 40	14.5	10.0	12.7	12.4 (10-16)	S
S. No. 44	8.0	5.5	9.0	7.5 (5-10)	MR
PBW 343 (Check)	12.0	18.0	13.3	14.4 (11-19)	S
PBW 502 (Check)	14.0	12.3	14.7	13.6 (11-16)	S
CD (0.05)	1.92	2.05	2.24	2.05	-

* Average of three replicates (nine plants over three years).

The lines were also evaluated against a mixture of races (46 S 102, 46 S 119 and 78 S 84) of stripe rust and of leaf rust (77-2, 77-5, 104-2 and 12-2). The severity of the diseases was scored following a modification of Cobb's scale (Petersen *et al*., 1948).

RESULTS AND DISCUSSION

Of the varieties earlier reported resistant to *H. avenae*, only two, AUS 15854 and AUS 15895, showed resistance to CCN pathotype Ha 41 with an average of 2.1 and 3.4 cysts per plant, respectively (Table II). AUS 15807 was moderately resistant while Raj MR-1, a variety resistant to CCN pathotype Ha 21, prevalent in Rajasthan and Haryana, was susceptible to the Ludhiana population of the nematode (pathotype Ha 41). Resistance in AUS 15854 to different population of *H. avenae* was reported earlier by Mathur and Dalal (1995) and Sharma and Sharma (2000) from Rajasthan. Of Karnal bunt resistant stocks and lines from the backcross population KBRL22/3*PBW 343, only one KB resistant line, KBRL 13, showed a CCN-resistant reaction (3.05 cysts per plant) whereas KBRL 10, KBRL 22, CMH 77.308 and H 567.71 were moderately resistant. Three lines from the cross KBRL22/3*PBW343 were moderately resistant. Moderate resistance may have been inherited from the parental line KBRL 22.

Two lines of synthetic wheat (S. No. 19-1 and 63) showed multiple resistance to CCN, Karnal bunt and to stripe and leaf rusts (Table III). These two lines had 2.3 and 3.0 cysts per plant and 1.3% and 3.1% Karnal bunt infection, respectively, and were resistant to both the rusts at the adult plant stage. Six lines (S. Nos 14-1, 23-2, 34-1, 45-2, 51-2 and 67-1) were resistant to Karnal bunt and stripe and leaf rusts but only moderately resistant to the CCN. All the lines showed resistance against Karnal bunt and had infection levels below 5% (Table III). Three lines (S. Nos 23-2, 60-1, 63) were totally free from stripe rust and nine showed resistant reactions. Thirteen lines remained free from leaf rust. Three lines (S. Nos 21-1, 24-2 and 31-2) were resistant to Karnal bunt and stripe and leaf rusts but susceptible to the nematode. Just one line (S. No. 15-1) was resistant to Karnal bunt and leaf rust, moderately resistant to CCN but susceptible to stripe rust. The line S. No 60-1 was resistant to Karnal bunt and stripe rust, moderately resistant to CCN but susceptible to leaf rust.

Multiple resistance in wheat to different diseases and nematode pests has been reported in several lines at CIMMYT (Singh and Rajaram, 2002). Resistance has also been reported in barley (cv. Morocco), wheat (cv. Loros) and oats (*Avena sterilis* L.) to Ha1, Ha2 and Ha3 groups of pathotypes of *H. avenae* and in cv. Nidar (oats) to Ha71 of the Ha1 group (Nicol, 2002). Under the All India Coordinated Project, resistance to CCN

Table III. Reactions of synthetic wheat lines to cereal cyst nematode, Karnal bunt, stripe and leaf rusts (2004-2006).

Serial Number (S. No.)	Cereal cyst nematode		Karnal bunt		Stripe rust		Leaf rust	
	Cysts/ plant	Reaction	Infection (%)	Reaction	Highest score	Reaction	Highest score	Reaction
S. No. 5-2	13.5	S	2.33	R	10 R	R	40 S	S
S. No.14-1	7.0	MR	2.33	R	10 R	R	Free	R
S. No.15-1	4.5	MR	1.33	R	40 S	S	Free	R
S. No.19-1	3.0	R	1.26	R	10 S	R	Free	R
S. No.21-1	5.0	S	1.53	R	5 R	R	Free	R
S. No.23-2	9.0	MR	0.46	R	Free	R	Free	R
S. No.24-2	14.3	S	3.03	R	TR	R	Free	R
S. No.31-2	10.5	S	3.73	R	5 R	R	Free	R
S. No.34-1	5.0	MR	2.10	R	5 R	R	Free	R
S. No.37-2	13.3	S	4.60	R	40 S	S	Free	R
S. No.45-2	6.5	MR	1.63	R	5 R	R	Free	R
S. No.51-2	5.0	MR	0.38	R	5 R	R	Free	R
S. No.60-1	3.0	MR	0.60	R	Free	R	20 S	S
S. No.63	2.3	R	3.10	R	Free	R	Free	R
S. No.67-1	5.0	MR	0.86	R	10 R	R	Free	R
PBW 343	25.0	HS	-	-	-	-	-	-
WH 542	-	-	48.4	HS	-	-	-	-
WL 711	-	-	-	-	80S	HS	80S	HS
CD (0.05)*	1.87	-	1.05					

* Pooled analysis for 3 years

has been reported in a few advanced breeding varieties only (Anonymous, 2007). Such varieties, however, did not possess resistance against the rusts as well as Karnal bunt. Varieties/lines of wheat showing multiple resistance are valuable for the incorporation of resistance into high yielding bread wheat.

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